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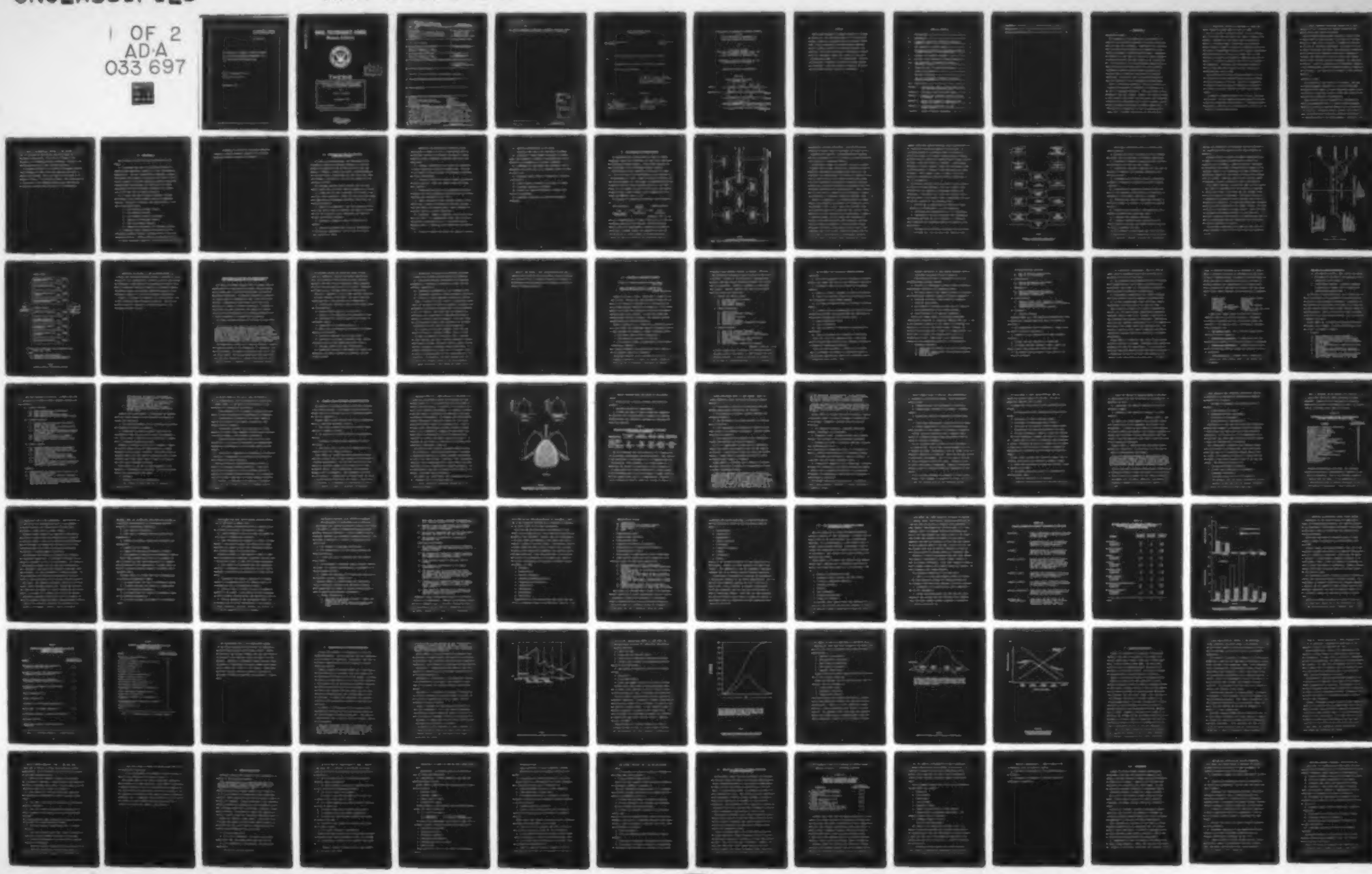

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UTILIZATION OF TECHNOLOGY TRANSFER CONCEPTS AS AN AID FOR ENGINEERING MANAGEMENT IN A TEST AND EVALUATION ORGANIZATION

NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

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Monterey, California

THESIS

UTILIZATION OF TECHNOLOGY TRANSFER CONCEPTS
AS AN AID FOR ENGINEERING MANAGEMENT
IN A TEST AND EVALUATION ORGANIZATION

by

Jack A. Grubber

September 1976

Thesis Advisors: J. W. Creighton
J. A. Jolly

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This thesis addresses Technology Transfer as it might be applied in a Test and Evaluation (T & E) activity for weapons systems and components within the Federal Government. Factors associated with the Technology Transfer process, aids and barriers to Technology Transfer, the innovative and creative processes, and managerial requirements for Technology Transfer are related to the job of an engineering manager in a T & E organization. From the relationships, a Paradigm for action

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NAVAL POSTGRADUATE SCHOOL
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TEST AND EVALUATION ORGANIZATION

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ABSTRACT

This thesis addresses Technology Transfer as it might be applied in a Test and Evaluation (T & E) activity for weapons systems and components within the Federal Government. Factors associated with the Technology Transfer process, aids and barriers to Technology Transfer, the innovative and creative processes, and managerial requirements for Technology Transfer are related to the job of an engineering manager in a T & E organization. From the relationships, a Paradigm for action for middle management engineers to improve technical capability by utilizing Technology Transfer concepts is formulated.

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I. INTRODUCTION

TECHNOLOGY TRANSFER

The importance of the application and utilization of scientific and technical knowledge for as many uses as possible has long been recognized. Congressmen have introduced bills to that end and statesmen have expressed the need to transfer technology to underdeveloped nations. Supervisors and managers are well aware of the need to update employees to avoid obsolescence and stay abreast of the state-of-the-art. The Director of the Defense Advanced Research Projects Agency has stated that there needs to be closer working relationships between defense-oriented scientists and engineers and the industrial and university technical communities. There needs to be a cross-fertilization of ideas and concepts to aid in technological breakthrough.

What is "Technology Transfer"? The term currently used to express the movement of information or technology into new use is "Technology Transfer". There are almost as many meanings as there are authors. However, the meaning intended in this study is the process by which science and technology developed by an organization for a specific purpose becomes adopted or adapted and applied by another organization. For technology to be transferred, it must be actually applied by another user. Secondary application may take place as a

result of traditional diffusion mechanisms or formal Technology Transfer programs [Welles, 1973, p. 42].

We are in an age of constant change. It is occurring at such a fast pace that new methods are needed to adapt to the changes. Innovation is the process that is utilized to adapt to or harness change. Innovation is a deliberate planned change to improve a system or accomplish an objective. Most cases of Technological Transfer are actually technological innovations [Miller, 1970, pp. 1-3, Schon, 1969, p. 84]. Innovation is based on a systematic, organized leap into the unknown. It utilizes scientific tools but it is a process of the imagination. Technology and Technology Transfer are tools of innovation that are used to help bring about a change [Drucker, 1970, p. 68].

The starting point of the innovation process is to tap the full power of man's innovativeness; that is to develop the creative aspects of the man - the use of imagination. The greatest potential source of innovation is probably in exploiting the creative talents with which each person is endowed.

In summary, Technology Transfer is a tool of the innovative process. And the innovative process operates best when coupled with imagination and creativity. Technology Transfer, imagination, creativity, and innovation are all woven into the processes of accomplishing change.

This thesis addresses Technology Transfer as it might be applied in a T & E activity for weapons systems and components within the Federal Government.

New and sophisticated weapons systems are being created as these words are being written. This trend will continue in years to come, even in the face of attempts at austerity on the part of the Federal Government. The state-of-the art is being continuously stretched. This continuing technological growth dictates that improved, and new test techniques be developed and formulated to test and evaluate the weapons systems before they are certified acceptable for operational evaluation. Tools for increasing the technological capability of test organizations include Technology Transfer, imagination, and creativity. All three are the backbone of the innovation process.

OBJECTIVE OF STUDY

The objective of this study is to formulate a Paradigm for Middle Management Engineers in a Test and Evaluation organization with respect to their Technology Transfer responsibilities so a plan can be made to effect more effective and efficient test techniques and procedures.

This objective will be accomplished by analyzing the duties and responsibilities of a typical middle management engineer in a Naval Air Systems Command, Test and Evaluation Field Activity. Available textual, journal, and scientific paper literature will be searched, analyzed, and applied to the responsibilities of the middle manager. Available litera-

ture, which is predominately related to the private sector, will be reviewed for the factors that would apply to a U.S. Government organization. This will be followed by the formation of a Technology Transfer Paradigm. Details of the methodology are given in the following sections.

A secondary objective is to present the managing engineer with a synopsis of some of the work which has been done to support the Paradigm. This will appear to the reader to be lengthy at times. It is believed, however, that understanding of the essence of the Paradigm requires some understanding of the work by others which has lead to its development.

II. METHODOLOGY

The objective of the study was accomplished in four steps:

A. An analysis was made of the responsibilities of a typical middle management engineer in a Test and Evaluation organization. This was accomplished by examining a typical Directorate Chief Engineer's position at the Naval Air Test Center by means of the Chief Engineer's position description, organizational relationships as exhibited by the formal organization chart and functional statements, and observation of the work that he actually performs.

B. A search was made of textual materials, journals, periodicals, and scientific papers related to Technology Transfer, innovation, creativity, and human behavior. Broad areas investigated were:

1. The Technology Transfer Process
2. The Innovation Process
3. The Technology Transfer Environment
4. Barriers to Technology Transfer
5. Aids to Technology Transfer
6. Managerial Requirements for Technology Transfer

C. Literature search findings were matched with the postulated Technology Transfer responsibilities of the middle management engineer. Factors affecting Technology Transfer in the middle management engineer's directorate were determined.

D. A Paradigm for action for the middle management engineer to improve technical capability by utilizing Technology Transfer concepts was suggested.

III. SUGGESTED PARADIGM FOR IMPROVING TECHNOLOGY TRANSFER

As stated in the Methodology, the formulating of the Paradigm for improving Technology Transfer in a Test and Evaluation organization was the last step of a four step process. However, to assist the reader in understanding how the various factors, characteristics, and related data apply, the Paradigm is presented at this time and supported in the following sections.

The Paradigm presents specific actions that the Chief Engineer might take to achieve improved capability as follows:

1. Communicate the need to innovate to the Branch Heads and Branch Chief Engineers. Ensure that they know that management emphasizes and encourages innovation, creativity, and Technology Transfer.

2. Analyze the background of the Chief Engineers, Branch Heads, and Section Heads to determine the amount of training each has had relative to basic management, the innovative process, and creative thinking.

3. Establish a program to correct deficiencies in training.

4. Analyze past innovations within the Directorate to see who and how accomplished. Use the data to assist in future planning of change.

5. Administer the Professional Preference Census Questionnaire (modified to suit) to professional and sub-professional personnel to determine the possible linkers, potential linkers, middlemen, potential stabilizers, and stabilizers.

6. Gradually redistribute the linkers and stabilizers to adjust inequalities within the organization. This may not be entirely possible because of disciplines, background, and other circumstances.

7. Utilize the linkers for opinion leaders, gatekeepers, and early adopters. Start the change process with them, where possible.

8. Encourage supervisors to use appropriate motivation technique with their subordinates dependent upon the category identification determined by the P.P.C..

9. Reward innovative actions through ratings, in-house publications, awards by professional societies, releases to local news media, and allowing points toward promotion for innovative behavior (within regulations).

10. Encourage: Symposia attendence, face-to-face involvement with other T & E organizations (Navy, Army, Air Force), face-to-face involvement with R & D activities and the National Bureau of Standards, paper preparation and presentation.

11. Listen to feedback and adjust the program as appropriate.

12. Maintain communication at all times.

13. Determine what areas need innovation and change.

14. Establish a formal program with goals, resources, plans, and establish a schedule of implementation once an innovation is determined to be worthy of adoption.

15. Promulgate the philosophy that reasonable risk is acceptable and failure will not be punished except for those who don't try.

16. Gradually adjust talent to ensure that a diversity is available.

17. Create positive attitude for an image of change.

18. Encourage transfer of personnel.

19. Provide for long term planning of resource and facility requirements.

20. Encourage utilization of creative development techniques.

IV. THE TECHNOLOGY TRANSFER PROCESS

To understand what actions should be taken to improve Technology Transfer and innovation, one must first understand the Technology Transfer process. This section presents the basic principles of the Technology Transfer process.

Morton has said that innovation is not just one simple act. It is not just a new understanding or the discovery of a new phenomenon, nor just a flash of creative invention, nor just the development of a new product or manufacturing process. Innovation involves related creative activity in all these areas. It is a process in which creative acts, from research through service, couple together in an integrated way for a common goal [Morton, 1971, p. 3].

The process of technological innovation can be simplified to:

Idea Generation		Problem Solving		Commercialization
and	⟶	and	⟶	and
Design Concept Formulation		Engineering		Diffusion

[Goldhar, 1976, p. 52].

This is a simplification of Figure 1 which is one of the often referenced concepts of the technical innovation process. Figure 1 meets our requirements if invention is replaced by innovation. Goldhar, Bragaw, and Schwartz feel that the innovation can be either product or process innovation. For purposes of test and evaluation the innovation would be

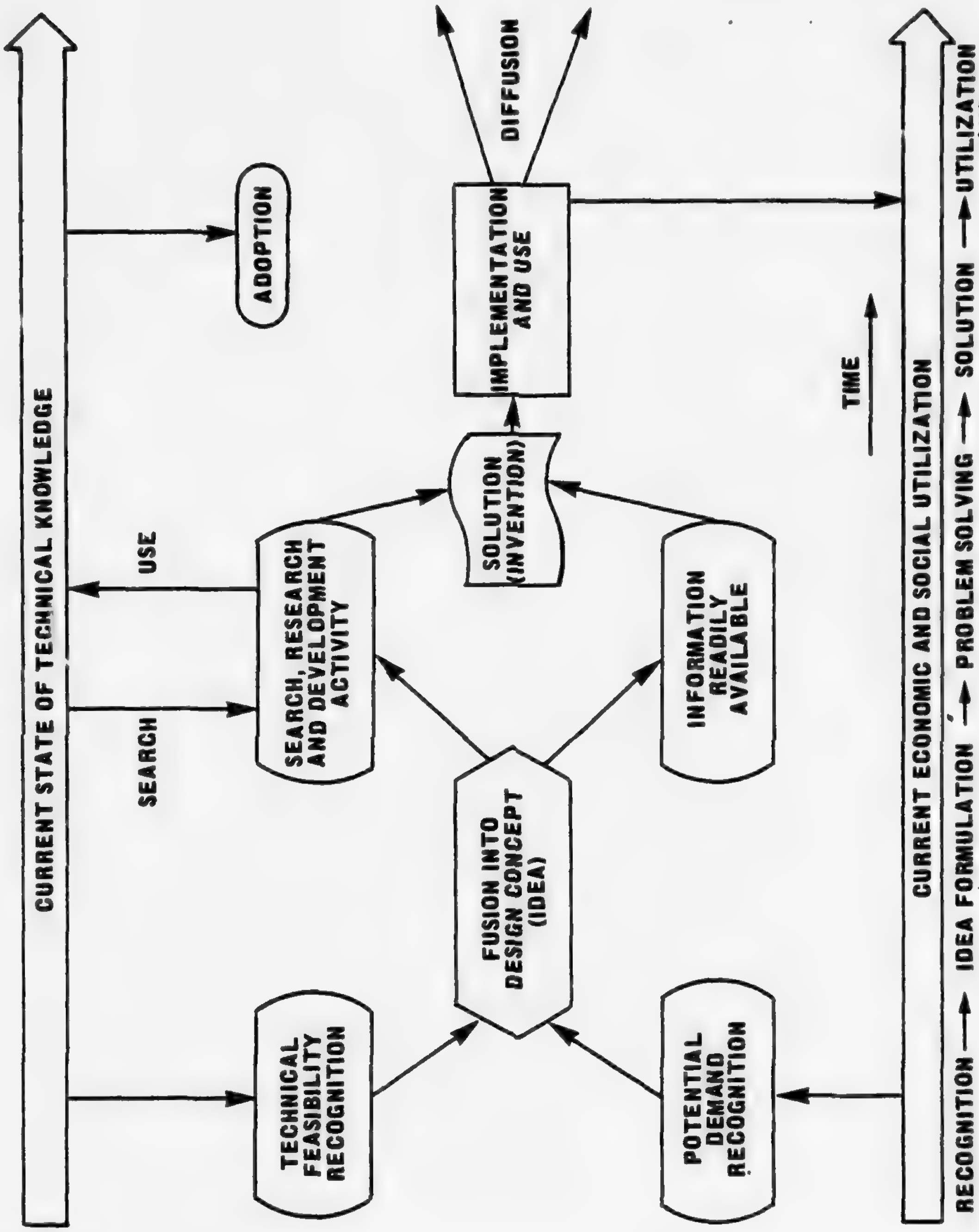


FIGURE 1

THE PROCESS OF TECHNICAL INNOVATION
(SOURCE: MYERS AND MARQUIS, SUCCESSFUL INDUSTRIAL INNOVATIONS, NSF 69-17, p.4)

predominately a process innovation. The innovation would be comprised of several areas of knowledge, but would typically be concerned with only one. Although primarily concerned with the utilization of R & D, the model is equally pertinent to all aspects of Technology Transfer.

Technological change and innovation occur as the result of complex sets of human interactions, information flows and transfers, individual and organizational creativity, and individual and organizational risk-taking and decision making. Each of these facets of the process involves human beings with their motivations, perceptions, attitudes, abilities, personalities, and prior knowledge and experience which mold information seeking and use characteristics. These variables must be dealt with or considered when attempting to improve the probability of successful innovation [Goldhar, 1976, p. 52].

Exhibit 1, Appendix B, is an expanded model by Goldhar, Bragaw, and Schwartz of the process of technological innovation [Goldhar, 1976, p. 53]. While the individual steps were intended primarily for commercial use, they are easily applicable to a Test and Evaluation organization. Recognition of Potential Demand could be replaced by Recongition of Potential Need; Market Research and Evaluation Activities could be replaced by Research of Potential Need; Market Development Activities could remain the same, but it must be remembered that it is now the "Testing Philosophy and Capability" that is being marketed. Additionally, marketing activities would be directed toward the Naval Air Systems

Command, other Navy systems commands, other military services, and contractors developing equipment for Navy use. R & D Activities leading to a prototype would be replaced by Activities Leading to Prototype; Commercialization Funding Decision would be replaced by Process/Product Funding Decision. The next to last step would be eliminated. Additionally, Inventory of Social, Economic, Human and Environmental Needs and Problems would be changed by deleting Social and adding Technical. These changes result in Figure 2 which is a process of technological innovation directly applicable to the T & E community.

The process described above is similar to that described by Gartner and Naiman [Gartner, 1976, pp. 25-26] as that identified by the Committee on Technology Transfer and Utilization. The process is a little more specific, but it does not allude to any specific order of performing the steps. The process consists of the following steps:

1. Collecting, or organizing and storing the results of research and development, i.e., the technology.

2. Publishing and disseminating the R & D information.

3. Identifying a need and evaluating the technological requirements that must be met to satisfy it. (Potential users identified and technology adapted or modified to meet their needs.)

4. Matching of the available technology with the specific need or ultimate use, with the aid of the potential users.

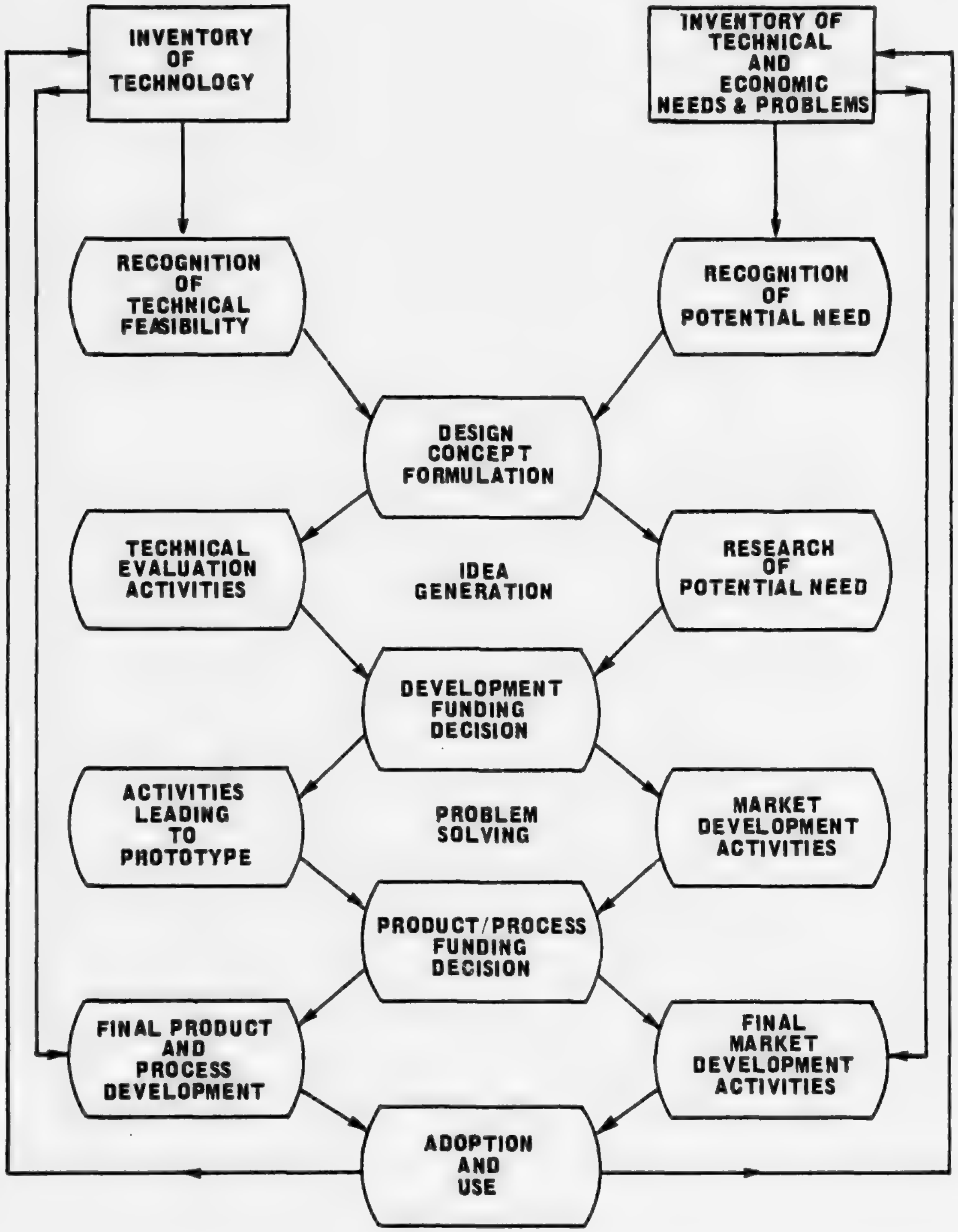


FIGURE 2

PROCESS OF TECHNOLOGICAL INNOVATION FOR A TEST AND EVALUATION ORGANIZATION

5. Executing a continuing series of relevant cost-benefit analyses.

6. Defining the market potential and other parameters that should help to determine the potential utilization.

7. Examining the possible consequences that may result from fulfilling the needs and their impact.

8. Locating the potential "suppliers" who are able and available to translate the technical information into practical reality.

9. Determining the resources and other requirements necessary for suppliers to produce the product, service, or process.

10. Associating the suppliers and users so they can agree on the standards, characteristics, performance, and constraints of the product, service, or process.

11. Performing the adaptive engineering necessary to develop the product or service or to acquire any missing elements.

12. Establishing a business or implementation plan to determine production and operational costs.

13. Acquiring the necessary financing.

14. Creating a marketing plan, production of the product, service or process and implementation of its sale at a price a purchaser will pay.

At first thought it would appear that item "14" would not be applicable to a T & E organization as far as purchase price is concerned. However, in these days of decreasing

funding, and competition for resources, more and more government organizations must market and sell their products and services.

Professor Everett M. Rogers developed a Paradigm similar to Figure 3 to illustrate factors known to affect the adoption of new technology. Rogers divided the environment for innovation into adopter characteristics, elements of the situation, nature of the technology, form and reliability of information sources, and the outcome of actual trials [Hough, 1975, pp. 58-59]. These are related to the central process of Awareness, Interest, Evaluation, Trial, and Adoption.

Jolly [1974] developed a predictive model for the coupling of the sources of knowledge with the utilizers of knowledge. He lists nine factors, four formal and five informal, which affect the transfer of technology. The formal factors can be classified as procedural and the informal factors can be classified as behavioral. At this point significant validating research has been conducted on the "Linker" factor. The Linker factor will be discussed in a later section. Once the factors are validated and weights developed for the factors by additional research, quantification of organizational effectiveness in transferring technical information can be developed. The model is presented in Figure 4.

The principle usefulness of the model at this time is in making individuals aware of the factors affecting Technology Transfer.

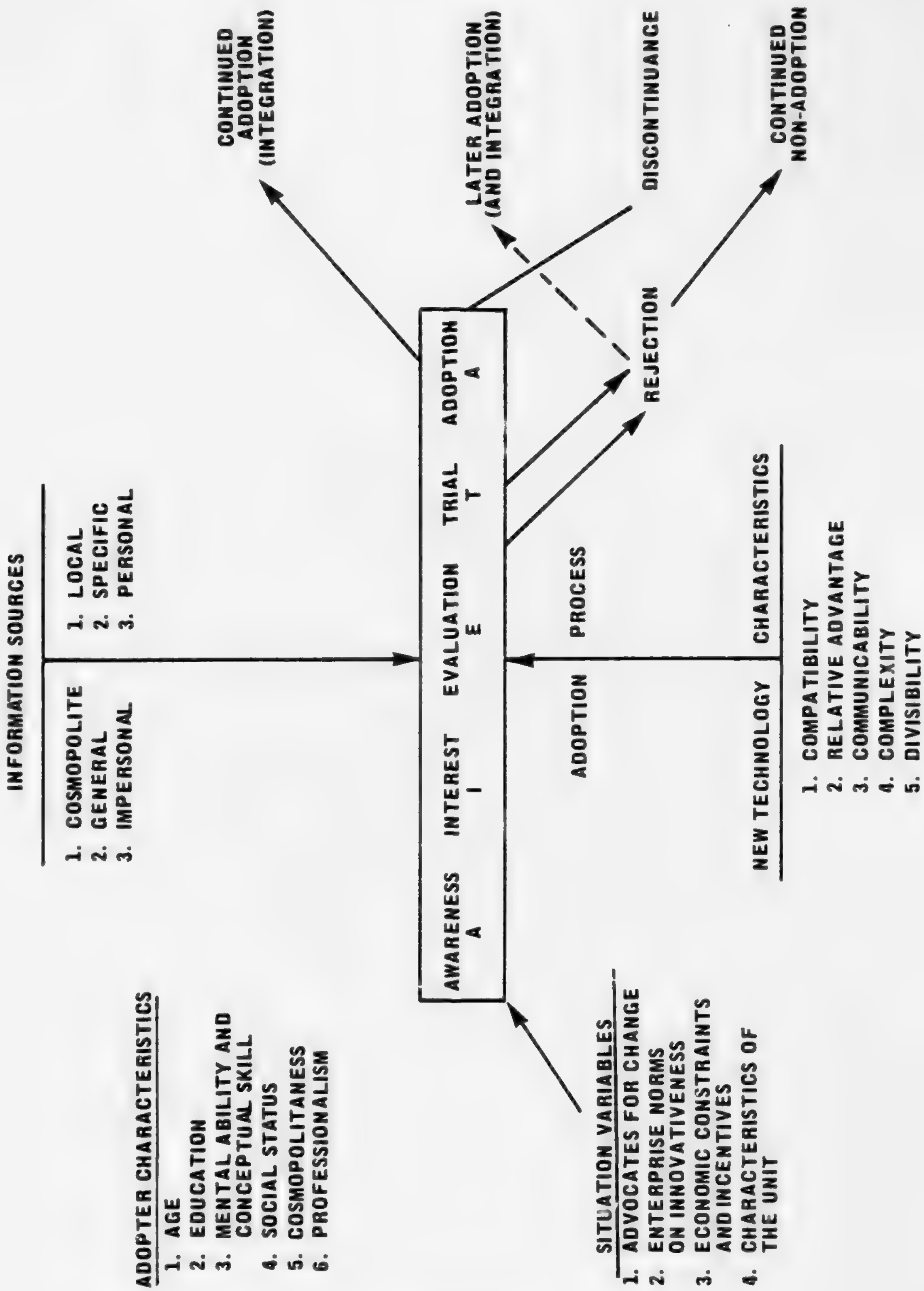
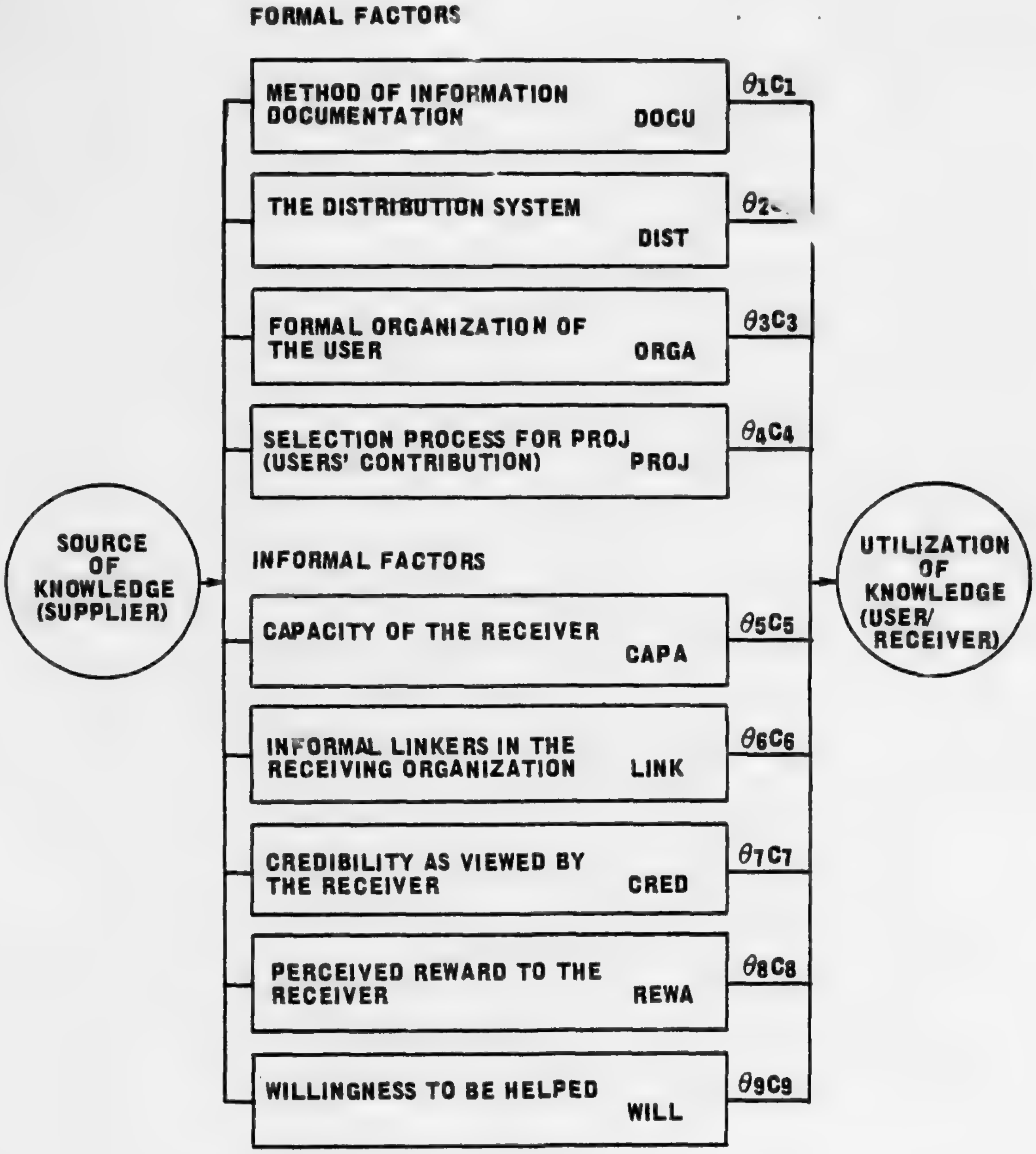


FIGURE 3

TECHNOLOGY ADOPTER PARADIGM



THE MODEL MAY BE EXPRESSED IN EQUATION FORM SUCH THAT:

$L_i = \Sigma \theta_1 C_1 + \theta_2 C_2 + + + \theta_j C_k$

WHERE

L_i = LINKER INDEX FOR AN ORGANIZATION I

θ_j = A MEASURE OF FACTOR UTILIZATION, θ_j RANGE 0 – 1

C_k = A MEASURE OF THE FACTOR CONTRIBUTION, $\Sigma C_k = 1$

FIGURE 4

PREDICTIVE MODEL OF TECHNOLOGY TRANSFER

As determined by analysis of the preceding models and processes, the Technology Transfer process is primarily a people process set in an organization. Therefore, many of the concepts and findings of human behavior and organization research can be used to understand Technology Transfer and innovative behavior. Succeeding sections will discuss literature related to these findings as applied to a Test and Evaluation organization.

Exhibits 2 through 4 of Appendix B are other authors' views of the Technology Transfer/Innovative process. They are presented to show the similarity of thinking related to the Technology Transfer process.

V. DESCRIPTION OF POSITION AND RESPONSIBILITIES OF A MIDDLE MANAGER OF A T&E ORGANIZATION

The Naval Air Systems Command (NASC) is charged with the responsibility of developing Navy Airborne Weapons Systems. These systems must be certified satisfactory and ready for Operational Evaluation. A Technical Evaluation is conducted on a given system or component in order to make this certification. Consequently, NASC directs one of its field activities to conduct a Technical Evaluation. The Naval Air Test Center has been selected by the author as a typical field activity for analysis of the Technology Transfer roles of middle management in accomplishing the mission.

The formal mission statement of the Naval Air Test Center is:

> "To perform test and evaluation of the total aircraft mission equipment, subsystems, components, related support systems and integrated logistic support elements; to provide technical advice and assistance to the Naval Air Systems Command, the Board of Inspection and Survey, other government agencies and contractors; to assist other R D T & E and O T & E activities in fulfilling their mission requirements; to conduct test pilot training; and to conduct in-house technical projects that develop and document test and evaluation technology."

The organization of NATC is as shown in Exhibit 1, Appendix A. The operating portion of the organization is composed of four test directorates, two support directorates and the U.S. Navy Test Pilot School. The Systems Engineering Test Directorate (SETD) has been selected as a typical directorate for the analysis. Exhibit 2, Appendix A, is a functional statement

of the responsibilities and supporting tasks of SETD. Exhibit 3, Appendix A, depicts the formal organization of SETD. For purposes of this thesis the Chief Engineer's position, code SY04, will be considered middle management and will be the position that will be studied. Comparable positions exist in the other three test directorates.

Exhibit 4, Appendix A, is the formal position description of the Chief Engineer of the SETD. The major duties and responsibilities of the position can be summarized as:

1. Provide final technical review of test plans, reports and correspondence.

2. Assures timely completion of work units.

3. Assists in the controlling of expenditure of funds.

4. Responsible for technical quality and adequacy of directorate output.

5. Responsible for assigning projects.

6. Major voice in planning and utilization of manpower, funding, and facilities.

7. Technical supervisor of the branch heads.

8. Supervises the Advanced Technology Group, Computer Technology Group, and the Engineering Service Group.

9. Provides liasion with other Directorates.

10. Supervises research and development to improve test techniques, procedures, information gathering, and data analysis methods.

11. Responsible for monitoring contractor development of aircraft and aircraft related systems and components.

12. Determines personnel requirements and recommends assignments or transfers of personnel to insure the most efficient organization.

13. Recommends reorganization to meet changing needs.

14. Recommends training to develop personnel capabilities.

15. Carries out Equal Employment Opportunity policies.

Items 4 through 14 are all related to Technology Transfer. Because of the nature of test and evaluation, equipment under development or prototype equipment make up the preponderance of the T & E effort. This means that the engineers and technicians must understand the underlying principles of operation of state-of-the-art equipment. They must design new, and frequently unique, test procedures and techniques to adequately test the state-of-the-art equipments.

The functions of the Chief Engineer (SY04) are also defined in Exhibit 5, Appendix A /NATC, 1975, p. SY-67/.

As seen by inspection of Exhibits 2 and 3, Appendix A, the Chief Engineer must have a working knowledge of Computers, Ground Support Systems, Electrical Systems, Aircrew Systems, Electronic Systems, and Ordnance Systems Technology. It is virtually impossible for one man to be an "expert" in all of the areas of technology that are the responsibility of the Directorate. Consequently, the Chief Engineer must rely heavily on the technical skills of the Chief Engineers of the branches and groups. This brings the reader to the

objective of the thesis. What actions should the Chief Engineer take to ensure that directorate technical personnel will continue to be, or become, innovative and creative in developing new test procedures and techniques, and will not become technically obsolete?

VI. BARRIERS TO TECHNOLOGY TRANSFER

There is nothing permanent except change.
Heraclitus

Every progressive spirit is opposed by a
thousand men appointed to guard the past.
Maurice Maeterlinck

Change is the way of life. Resistance to change is also a way of life. The only way that successful change can take place is to overcome the resistance to it and provide the proper organizational conditions to enhance it. For a middle manager to overcome the resistance he must first understand something about these barriers. He must also understand organizational barriers to change. This section discusses organizational and behavioral barriers.

Based on studies by A. D. Little Inc., Industrial Research Inc., and others, the Technology Transfer environment consists of three systems which enhance or impede Technology Transfer:

1. The General System (Total Organization)
2. The Subsystems (Department or Division)
3. The Elements (People in departments directly involved in Technology Transfer.)

This concept highlights the institutional factors which prevent an optimum transfer of technology.

Technology Transfer can be initiated at any level if goals are mutually consistent. If goals are diverse, Technology Transfer will not be initiated. When goals are mutually

acceptable, goal directed behavior is started. This does not assure successful Technology Transfer because of the existence of barriers. Because of goal conflicts or insurmountable barriers, less than optimum Technology Transfer and utilization is accomplished. Exhibit 1, Appendix C, illustrates this concept. Specific barriers that may prevent transfer activity between the systems are:

1. Between the General System:

   a. No formal transfer policies
   b. Cost barriers
   c. Time horizon conflict
   d. Infringement problems

2. Between Subsystems:

   a. Inertia barrier
   b. Lack of an incentive structure
   c. Cost barrier
   d. Communication barrier
   e. Time barrier
   f. Geographic distance
   g. Non-existent transfer management structure
   h. Technology barrier

3. Between Elements:

   a. Lack of an incentive structure
   b. High risk of being blamed for failure
   c. Insecurity of retaining job if not successful
   d. Mutual disrespect
   e. Unique requirements of each subsystem
   f. Updating of technology needs
   g. Time barrier
   h. Lack of transfer organization managers

/Gartner, 1976, pp. 22-23/.

To gain insight into the barriers to Technology Transfer in the public sector, Mock /1974, p. 303/ examined the nature of existing problems. He listed 26 barriers to innovation. Eleven of them are equally applicable to a T & E environment.

1. The problems have constantly changing boundary conditions.

2. The criteria against which we can measure a successful solution may change while we are still working on the problem.

3. Solutions to many of the problems are exceedingly expensive.

4. There is a lack of consensus of goals and priorities.

5. There is an inherent dilemma in our political process with its emphasis on short-range planning.

6. The highly fragmented nature of the public technology market.

7. A general lack of communications and effective working relationships between those groups which are generating new science and technology and the potential users.

8. Lack of sufficient funds.

9. Lack of personnel.

10. Lack of interest of news media in science and its application.

11. Lack of incentives for innovation or creativity.

While item ten is not completely true, it does have specific bearing where publicity for incremental innovations is desired for motivational purposes.

Jervis and Sinclair [1974, p. 141] refer to Doctors' study of government involvement in Technology Transfer in which Doctors suggested some barriers to horizontal transfer of technology across mission lines:

1. Mission orientation of most agency technical personnel.

2. Vertically integrated nature of agencies.

3. Institutional barriers to information flow in the aerospace/weapon systems industry.

4. Low rate of technological mobility from the aerospace/weapon-system industry to the commercial sector.

5. Low value placed on the transfer function by scientific and technological personnel engaged in Federally sponsored R & D.

6. Political attitude of institutions for transfer.

7. Security restrictions.

8. Poor methods of information retrieval and evaluation.

9. Poor understanding of the transfer process.

10. Power structure of the agencies themselves.

Cetron lists among others the following paraphrased "Characteristic Barriers to Innovation" [Cetron, 1976, pp. 17-18]. He was referring primarily to the transfer of technology from Federal R & D to use by the public sector. However, the barriers are also applicable to Navy T & E organizations. Also, where "user" is stated, the meaning would be the T & E organization as user. There needs to be communication between the user organization and the R & D laboratories.

1. Laboratory Barriers:

   a. Conflicting motivations on the part of professional personnel.
   b. Inadequate communications with the user community.
   c. Lack of initiative.
   d. Limited money.

2. Developer/Producer Barriers:

   a. Lack of advisory participation.
   b. Lack of R & D synthesis.

3. Technological:

   a. Lack of appropriate reliability.
   b. Technology turnover rate.

4. Managerial:

   a. Lack of familiarity with users.
   b. Personnel retraining requirements.
   c. Established competition.

5. Institutional:

   a. Nature of firm - size, stability, outlook, existing distribution channels, R & D orientation, organizational structure.
   b. Competition with existing customers.

6. Financial:

   a. Need for funding.

Thompson [1965, pp. 1-20] discusses characteristics found in bureaucratic organizations which serve as barriers to innovation:

1. The organization often is monocratic: There is only one point or source of legitimacy.

2. Conflict is not legitimitized and this depresses creativity.

3. Control over all resources is centralized.

4. It offers extrinsic rewards of money, power, and status, rather than satisfaction from one's work.

5. The reward structure places a high value on compliance and conformity.

6. In a monocratic organization, there is veto but no appeal; such an organization may allow new ideas to be generated, but is apt to veto them.

7. The characteristic psychological state in a bureaucratic organization is one of anxiety and chronic dissatisfaction; this leads to a conservative orientation in which innovation is perceived as threatening.

8. Bureaucratic organizations are staffed primarily with "desk classes" and only minimally by professionals.

9. In such organizations, praise and blame attach to jurisdictions; one feels that he can only fail once.

Item 2 has been included for a sense of completeness. However, in a Military-Civilian professional organization legitimate conflict does exist. However, it may not be as high a magnitude as required for innovation. Additionally, there are many competent professionals in a T & E organization which would tend to make item 8 only partially true. The problem is caused by Civil Service Regulations and funding restrictions limiting supervisors flexibility in combating obsolescence.

Miller [1970, p. 168] feels that there are four groups typically involved in a change: Employees, staff specialists, managers, and first line supervisors. It is not only the production employees whose attitude may affect the success of an innovation, but any of the other three groups as well - managers, staff specialists, and supervisors. He refers to

Zander in defining resistance as an expression of "behavior" which is intended to protect an individual from the effects of real or imagined change. The general form resistance takes is an expression of hostility which could be revealed as agression against the administrator or the change itself. Some expressions of resistance are found in all four groups. Miller cites several sources, but the forms can be summarized as:

sloppy effort	social action (strikes, etc.)
inefficiency	absenteeism
grievances	sullenness
high turnover	harder work
restriction of output	requests for transfer
aggression against manager	quarrels
development of unhappy cliques	expression of why the change will not work

A significant human barrier to successful innovation sometimes arises in the form of resistance of managers. Resistance by managers can have a far greater impact than resistance at the employee level. Some forms of resistance found in managers are:

1. <u>The Negative View</u>: One of the most common forms of resistance found in managers.

2. <u>Unconscious Dissension</u>: An organization man type of unquestioning acceptance but with buried doubts or misgivings.

3. <u>Apathy and Indifference</u>: A manager sees his role as merely implementing whatever changes are presented to him by top management.

4. <u>Free Translation</u>: A manager bends a change into his own purposes and ideas without regard to the overall plan of top management.

5. <u>Managers can cause resistance by</u>:

a. Pet Project Attitude - Push tactics may engender resentment on the part of the people who will be taking part in the change.

b. Authoritarian Approach - Summarily demanding introduction of change into an organization without proper ground work.

In the case of staff specialists, it is likely that the form of resistance will be expressed by erecting barriers to the ideas of others regarding the change. Frequently, the staff specialist bring certain blind spots to his work that will get him into trouble when he helps initiate change with operating people. That is, he cannot see that his change is not perfect and could be made better. He is not receptive to change of his plan.

Miller [1970, pp. 175-178] also discusses the reasons that people resist change. He lists reasons found by his own, Davis', and Zander's studies.

1. Miller:

a. Inept approach of methods analysts.
b. Personnel shortage during implementation.
c. Failure to justify reasons for the change.
d. Top management pressure for fast installation of the change.
e. Lack of participation by supervisors and key employees.
f. Poor planning for transfers of personnel.
g. Insufficient guidance to people affected by the change.
h. Lack of enthusiasm for the change by managers and supervisors which affected employees.
i. Lack of advance information on the change.

2. Davis has classified resistance to change under three broad categories of economic reasons, personal reasons, and social reasons:

a. Economic reasons:

(1) Fears technological unemployment.
(2) Fears reduced hours.
(3) Fears demotion and reduced wages.
(4) Fears speedup and reduced incentive wages.

b. Personal reasons:

(1) Resents implied criticism that present method is inadequate.
(2) Fears that his skill, and personal pride in it, will be reduced.
(3) Expects greater specializations, resulting in boredom, monotony, and decreased sense of worthwhileness.
(4) Dislikes effort required to relearn.
(5) Fears harder work will be required.
(6) Resists change because he doesn't understand it.

c. Social reasons:

(1) Dislikes making new social adjustments.
(2) Dislikes breaking present social ties.
(3) Fears the new social situation will bring reduced satisfaction.
(4) Dislikes outside interference and/or some of the persons making the change.
(5) Resents lack of participation in setting up the change.
(6) Visualizes the change as mostly benefitting the company, rather than him, his fellow workers, or the general public.

3. Zander:

a. Resistance can be expected if the nature of the change is not made clear.
b. Different people will see different meanings in the proposed change.
c. Resistance can be expected when those influenced are caught in a job between strong forces pushing them to make the change and strong forces deterring them from making the change.

d. Resistance may be expected if the change is made on personal grounds rather than impersonal requirements or sanctions.

e. Resistance may be expected to the degree that the persons influenced by the change have pressure put upon them to make it.

f. Resistance may be expected if the change ignores the already established institutions in the group.

Pearson and Rickards [1974, p. 67] discuss two problems which can create barriers to the successful utilization of science and technology.

1. The not-invented-here (N.I.H.) syndrome, which affects the matching of solutions to problem.

2. Communications problems between those with the knowledge and those who may be able to put the knowledge to use. This barrier is often due to the inability to communicate in a language understood by both.

Everyone is familiar with the N.I.H. syndrome. However, the barrier caused by lack of communication in a common language is not as widely considered. Each side's ideas are rejected because the other doesn't really know what is being proposed; and, either doesn't want to know or is afraid to show his lack of knowledge by asking.

Watson [1975, p. 15] is a bit more pragmatic in his analysis of the barriers to creativity. He does not exclude others, but specifically lists three:

1. Laziness.

2. Inability to perceive opportunities.

3. The attitude or belief that one is incapable of becoming creative.

Creativity, which in one way is also the ability to perceive opportunities, will be discussed in a later section.

Bright [1964, p. 133] makes five observations on the resistance to technological innovations.

1. The resistance will be somewhat in proportion to the extent to which institutions and individuals are threatened.

2. Resistances are lessened if only slight change in behavior on the part of individuals, institutions, and organizations are demanded.

3. Innovations encounter less resistance in a firm, industry, or society where managers and workers are accustomed to frequent changes in the technical environment.

4. Those advocating innovation often tend to be over optimistic as to the time and feasibility of accomplishment, although not necessarily as to the ultimate impact on their concept.

5. Resistance is aggravated or encouraged if the innovator is sarcastic, contemptuous or insulting in his reference to other devices and their advocates.

There has been much literature published related to barriers to Technology Transfer/Innovation. While this section did not discuss all of the literature related to barriers to Technology Transfer/Innovation, it is representative and provides a good base for middle managers interested in the subject. A knowledge of the barriers is necessary before action can be taken to reduce or eliminate barriers to change.

VII. FACTORS AIDING TECHNOLOGY TRANSFER/INNOVATION

The barriers to Technology Transfer have been discussed in the previous section. The purpose of this section is to discuss some of the factors that aid in Technology Transfer, the tool of innovation.

Schwartz [1975, p. 8] indicated that once an organization elects an innovative strategy, it must:

1. Make timely resource allocations to exploit opportunities or respond to threats.

2. Be selective so limited resources are appropriately invested.

3. Encourage risk-taking among employees who may be risk averse.

4. Distribute risks so they can be managed and are at acceptable levels for each participant.

Myers [1965, pp. 91-96] feels that innovation requires long term planning which in turn requires the self-discipline of delayed gratification. He also feels that the rate and quality of innovation depend on the interaction of three management groups: Staff technologists, line operation managers, and top management. Each management level must want to innovate. "Somebody must continually push the innovation process against hostilities and inertia." Since innovation flourishes in an atmosphere of anticipation of innovation, an innovative climate is desireable and necessary.

Boettinger [1970, pp. 4-14] presents an interesting idea. He plots the relationship between Effectiveness and Human Tension, Figure 5a. It is interesting that some amount of tension seems desireable. An increase of mild tension up to point B will increase effectiveness. An increase in tension beyond that which is optimum for an individual will result in decreased effectiveness. He likewise plots Effectiveness against Technological Capability, Figure 5b. This curve plots effectiveness versus the technology used. Like the previous curve, effectiveness decreases beyond an optimum value. As an illustration, digging the Panama Canal with spades would be represented at point D; whereas, using a bulldozer to cultivate the garden could be at point F. By combining the two curves, he arrived at the following three-dimensional relationship, Figure 5c.

The inverted bowl's surface represents possible states of the combination. Both relationships must be controlled by management/supervision if overall optimal effectiveness, the top of the inverted bowl, is desired. Poor technological capability can be compensated for to some extent, with great leadership, and poor leadership with superb technology. But peak performance can never be achieved without peaks in both domains - the human and the technical.

Gold [1975, pp. 24-27] states that technological development programs offer five primary benefits:

1. Attain competitive advantages through new or better products or processes.

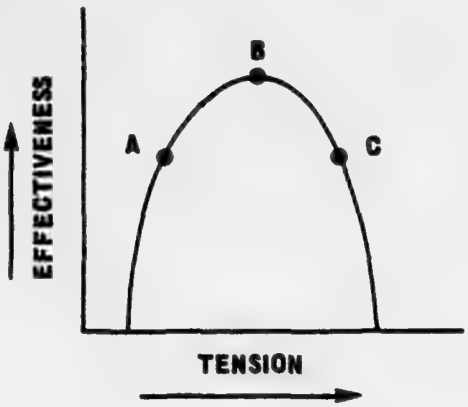


FIGURE 5a

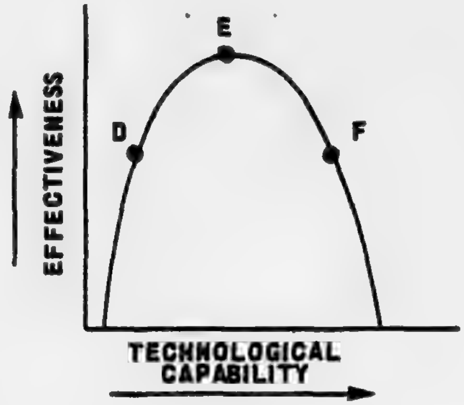


FIGURE 5b

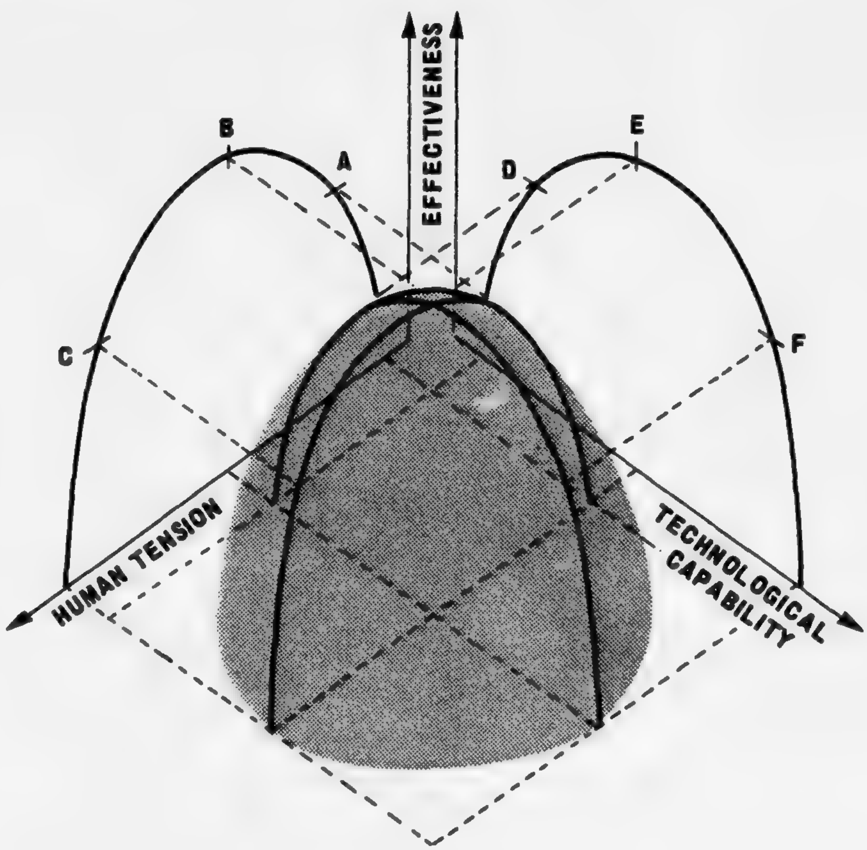


FIGURE 5c

FIGURE 5

THREE-DIMENSIONAL RELATIONSHIP OF EFFECTIVENESS, HUMAN TENSION, AND TECHNOLOGICAL CAPABILITY

2. Obtain knowledge which can itself be sold advantageously.

3. Keep up with, or avoid injurious lags behind competitors.

4. Minimize prospective disadvantages.

5. Provide the image of highly progressive management.

She presented the following table to compare five important characteristics for alternative strategies in achieving the above five benefits.

TABLE I

SELECTED CHARACTERISTICS OF ALTERNATIVE STRATEGIES FOR ADVANCING TECHNOLOGY

Alternatives	Development Cost	Success Probability	Time to Fruition	Likely Rewards	Associated Disruptions
Evolutionary improvements	Low	High	Short	Small	Small
Licensing	Low	High	Short	Moderate	Small/Large
Scale Increases	Moderate	Moderate	Moderate	Moderate	Small
Major Advances	High	Low	Long	Large	Large

The two strategies that would concern a T & E organization are Evolutionary Improvements and Major Advances. Most instances of the advancement of technology in a T & E organization would be evolutionary. Major advances, i.e., establishment of a completely new facility or capability do occur; however, in a T & E organization the Success Probability of a Major Advance is more dependent upon the need and support of higher authority than the support within the T & E organization. Therefore, success probability could be either low or high for Major Advances.

Gartner and Naiman [1976, p. 25] suggest that, for certain industrial cases, successful Technology Transfer requires:

1. The setting of specific and consistent goals and policies among parties involved in the transfer.

2. The adherence to specific criteria developed for Technology Transfer.

3. The development of a formal structure to bring the goals to fruition.

4. The minimization or elimination of barriers at the three levels of the transfer environment. (General system, subsystem and elements.)

5. The designation and existence of an individual(s) to oversee and coordinate the transfer process.

In a T & E organization the need for an individual(s) to oversee the process would depend on the size and scope of the project. A small project would not require an overseer. However, a large project or program involving the entire directorate would require an overseer.

Bright [1953, p. 55] feels that a diversity of talents and mental attributes is needed in an organization in order to achieve Technology Transfer.

> "I must also emphasize the necessity for diversity of talents, training, and attributes of mind in those working cooperatively toward a complex technical objective. I should like to say a word or two about the significance of mental attributes. If we take a cross section of productive research workers, perhaps by studying the authors of articles in the better journals, we find represented at least six kinds of minds: (1) the promethean or creative, (2) the critical and analytical, (3) the cumulative and inductive,

(4) the cumulative and descriptive, (5) the meticulous, and (6) the routine industrious. It is evident that more than one of these attributes is found in any given individual, although one will generally predominate.

History has shown that all these mental attributes have important roles to play in the round and steady growth of all branches of science and engineering, and we would be guilty of intellectual snobbery if we discounted any one of them."

Miller [1970, pp. 54-55] feels that to develop a capacity to encourage change it is first necessary to concentrate on how to manage. Management training should include the following:

1. The manager's functions - planning, organizing, leading, controlling, and innovating.

2. Managing of work - methods analysis work standards systems, work schedules, setting performance standards.

3. Managing the worker - selecting, training, disciplining, evaluating, and so on.

After increasing the managerial skills, it is necessary to develop a greater understanding of the innovation process.

1. Principles and techniques of creative thinking - how to generate more and better innovative ideas.

2. Learning the manager's role in innovating - developing proposals for innovations; facilitating innovations proposed by others; how to evaluate the potential of an innovation; techniques for programming an innovation; and techniques for implementing an innovation.

The manager needs sensitivity and skill in handling of change - human problems; resistance to change, facilitating adjustment to change.

Miller further feels, as many do, that communications are important in facilitating change. This communication should include:

1. Announcing plans for developing the innovation.

2. Keeping people informed of the change - including reasons.

3. Maintaining effective communication during change-over.

4. Preventing communications' barriers after the change.

5. Using communications to facilitate individual and group adjustment to the change as it continues in operation.

Another important additional skill a manager should develop is creating attitudes among subordinates that view change as a positive phenomenon.

All of the points made by Miller are very important in a T & E organization. Most of the civilian managers have come up through the ranks. Consequently, they are almost exclusively trained as engineers or scientists. They have had some training as supervisors and managers. But it is my opinion that most are still technically oriented at heart. Training in all of the above areas should be mandatory. Probably the area most lacking is that of creative thinking and management of innovation.

It is of vital importance for managers to become leaders of change. This statement is supported by Miller, "It is clear then that the starting point of the innovation process is to

tap the full power of man's innovativeness, that is, to develop the creative aspects of the man - the use of imagination [Miller, 1970, p. 86].

A program that could result in more innovations would include:

1. Overcoming the forces inhibiting creative decision making.

2. Principles of creative decision making.

3. Techniques for generating creative ideas.

4. The steps in the creative decision making process.

5. Determining the innovation potential of an idea.

6. Gaining acceptance of ideas as a basis for decision.

The four ingredients a manager must have to be innovative are: Creative ability; skill in evaluating ideas generated by creative thinking; the ability to concretize the proposal for innovation; and the ability to prepare a program for implementing the innovation that overcomes the obstacles to change.

Miller refers to Watson and Glaser who suggest that the following steps should be considered in making a change:

1. Make clear the needs for change and provide a climate to identify such needs.

2. Encourage group participation in clarifying and expanding these needs.

3. State the objectives to be achieved.

4. Establish broad guidelines for achieving the objectives.

5. Leave the details of change planning to the parts of the organization that will be affected by the change and must implement the plan.

6. Communicate the benefits expected as a result of successful change.

7. Materialize the benefits or rewards; i.e., keep promises.

[Miller, 1970, p. 159].

Cox [1976, pp. 29-32] suggests that successful innovation depends first on top management and secondly on an entrepreneur. He feels, as many others do, that innovation is a people process and depends on the people an organization employs, the environment in which they operate, and their ability to plan and implement those plans to meet the organization's goals and strategies.

Drucker [1970, p. 130] feels that long range planning is necssary for innovation. He feels that it is the only way to improve entrepreneurial performance.

> "It is the continuous process of making present entrepreneurial (risk-taking) decisions systematically and with the best possible knowledge of their futurity, organizing systematically the efforts needed to carry out these decisions, and measuring the results of these decisions against the expectations through organized systematic feedback."

Jervis, using data collected during project SAPPHO studied the difference between success and failure in 70 innovations. The results show little support for the "Product Champion" but do suggest that the power, commitment, and experience of the Innovation Managers are crucial factors [Jervis, 1975, pp. 15-25].

The study indicated that successful innovations could be distinguished from unsuccessful innovations by superior performance in five areas:

1. Strength of management and characteristics of managers.

2. Understanding user needs.

3. Marketing and sales performance.

4. Efficiency of Development.

5. Effectiveness of Communications.

Additionally, it was found that diversity of experience characterized managers of successful innovation projects. In these cases, user needs were outside the innovative organization. In the case of a T & E organization, it is its own user; user needs would then be the kind and quality of tests and techniques that are needed.

Ten "outstanding" innovations were studied by Globe, Levy, and Schwartz to determine what events and factors played key roles in the innovation process /Globe, 1973, pp. 8-15/. They studied 21 factors as to their degree of importance to each of the decisive events of the ten innovations. The factors were related to:

1. Various motivational influences.

2. Actions taken consciously by management.

3. Management involvement.

4. Peer group forces on the R & D scientists.

5. Circumstances that are usually unplanned or accidental.

6. External factors that form the general environment within which the innovative process takes place.

Table II presents the percentage of all decisive events for which that factor was judged moderately or highly important. Ranking first is Recognition of Technical Opportunity and second is Recognition of Need. The external factors, in general, rank toward the bottom.

TABLE II

PERCENTAGE OF DECISIVE EVENTS RATED MODERATELY OR HIGHLY IMPORTANT FOR EACH FACTOR

Factors	Percentage of Decisive Events
Recognition of Technical Opportunity	87
Recognition of the Need	69
Internal R & D Management	66
Management Venture Decision	62
Availability of Funding	62
Technical Entrepreneur	56
In-house Colleagues	51
Prior Demonstration of Feasibility	49
Patent/License Considerations	47
Recognition of Scientific Opportunity	43
Technology Confluence	36
Technological Gatekeeper	30
Technology Interest Group	29
Competitive Pressures	25
External Direction to R & D Personnel	16
General Economic Factors	16
Health and Environmental Factors	15
Serendipity	12
Formal Market Analysis	7
Political Factors	5
Social Factors	4

Several generalizations were made. The technical entrepreneur was also a "characteristic" important in nine of the ten innovations. This is the strongest conclusion that emerged from the study. If any suggestion was to be made as to what should be done to promote innovation, it would be to find technical entrepreneurs. Early recognition of the

need appeared in nine of the innovations. This confirms the high rating for the corresponding factor in the analysis of the decisive events, and substantiates the importance attributed to "market pull" in other studies.

Adequate funding emerges as an important consideration, both from the study of the case histories and the study of the decisive events. Seven of the innovations had Government support, although this support was limited for one of them. Furthermore, where all sources of funds were considered, Availability of Funding ranked near the top.

The situation with respect to confluence of technology was especially interesting. An unplanned confluence of technology was important to six of the innovations. But confluence of technology was present for the other four innovations as well, although it came about from deliberate planning, rather than accident. For three innovations of improved grains, technology confluence occurred because agricultural sciences is itself an interdisciplinary field, and has long been supported on that basis. The remaining innovation, made use of a deliberately formed interdisciplinary team. Technology Confluence also ranks near the middle as a factor influencing the decisive events. The lesson to be learned here is that the benefits of technology confluence should not be left to accident, but should be promoted through deliberate interdisciplinary research.

Much of the literature indicates the importance of the innovator's environment. Goldhar, Bragaw, and Schwartz

[Goldhar, 1976, pp. 51-60] felt that there are at least six identifiable characteristics of environments which are conducive to technological innovation:

1. Easy access to information.

2. Free flow of information both in and out of the organization.

3. Rewards for sharing, seeking, and utilizing "new" information.

4. Rewards for risk taking.

5. Rewards for accepting and adapting to change.

6. Encouragement of mobility and interpersonal contacts.

While these characteristics tend to be axiomatic, it must be pointed out that risk taking must be in congruent with the desires of the organization. In other words, the would be innovator should be rewarded for prudent but not imprudent risks.

Halloman [1966, pp. 35-36] makes four recommendations for achieving technological change:

1. We should reduce the cost of technological change.

2. We should increase the benefits of technological change to the innovator-entrepreneur.

3. We should reduce all risks of technological change to the innovator-entrepreneur.

4. We should increase the pressure for technological change.

Preliminary work with United Kingdom managers [Pearson, 1974, p. 72] seems to suggest that:

1. The general atmosphere/attitude of problem solvers can influence both quality and quantity of ideas.

2. Simple mechanistic devices can jog individuals out of set ways of thinking about problems.

3. When individuals are replaced by a group, the other members of the group can supply the stimuli, but special procedures are needed to deal with interpersonal behavior which reduces chances of ideas surviving.

Willenbrook [1974, p. 311] examined a number of cases where technology was successfully transferred from the public to the private sector. He made the following conclusions:

1. The transfer of Technology from idea formulation, to research, to development, to utilization, can be aided by management coordination and anticipation of future requirements.

2. Focusing of the method of approach of a research program in a recognized need by the ultimate user of the technology can aid in accomplishing transfer.

3. Review of the R & D effort can lead to changes of emphasis of the effort. Such analysis can avoid accepting the first workable solution rather than seeking the best one.

4. Careful planning of the experimental trials of a development should include consideration of what methods will encourage confidence, cultivate interest, and clarify incentives for the application of the technology.

5. Cost/benefit analysis is an effective management tool.

6. The development of technologies can be best done in an environment where various disciplines interact with freedom.

Cook [1974, p. 540] in discussing Technology Transfer in partially developed countries, listed six elements that are absolutely essential for successful Technology Transfer. Five that would be pertinent to a Navy T & E organization are listed below:

1. The transfer of knowledge and know-how.

2. The availability of all the needed equipment and starting materials.

3. A real felt need, a conviction that the transfer must succeed.

4. An environment - political, legal, economic, cultural and social - of positive encouragement; a willingness to cut through manmade barriers.

5. Taking full advantage of all beneficial local factors - raw materials, people, location, etc..

Thompson [1965, pp. 1-20] analyzes the relationship between bureaucratic structure and innovative behavior. He makes suggestions for changes to increase innovativeness in terms of general and structural requirements.

1. General Requirements:

   a. There must be resources available - money, time, skills, and good will.
   b. A diversity of inputs should be allowed, since this is needed for the creative generation of ideas.

c. There must be neither a complete commitment to, nor a complete alienation from, the organization.

d. Rewards in such an organization come primarily from the search process, professional growth, and the esteem of colleagues.

e. The creative atmosphere must be free from external pressure, one waits for the best solution.

f. The innovative organization is primarily a professional one.

2. Structural requirements:

a. The innovative organization should be relatively loose structurally; job responsibilities will not be narrowly defined.

b. The organization should not be highly stratified; there should not be "awesome" status differences, and communication should flow freely.

c. Group processes should be used more than at present.

d. The innovative organization is not highly departmentalized.

e. The simplest unit in the organization should not have a highly specified task, but should be an integrative unit of professionals and support personnel. The organization of these units should be project oriented.

f. Ideally, such an organization should be capable of restructuring itself in the light of changing tasks. Leadership should be rotating rather than constant.

g. There should be "devaluation" of authority and positional status and the recognized, official sharing of power and influence.

Thompson's General Requirements appear to be achievable in a Navy T & E organization. However, the structural requirements are a different case. A military organization cannot be loose structurally nor can there be a devaluation of authority. Additionally, because of the nature of T & E organizations,

specialization and departmentalization is necessary. However, some of the supressive effects can be mitigated or compensated for by extra effort in the other requirements.

The views and data selected for presentation in this section of the study are but a few of many that have been promulgated in the literature. However, they are representative of the work, data, and thinking on the subject and tend to "home-in" on many of the same factors. The National Institute of Mental Health has made a study of much of the available literature which fairly well summarizes the important factors affecting innovation. Nine characteristics of an innovation which affect the probability of its adoption are listed in the N.I.M.H. Distillation of Principles on Research Utilization [1972, pp. 7-8].

1. Relevance
2. Compatibility
3. Relative Advantage
4. Observability/Communicability
5. Complexity and Feasibility
6. Reversibility
7. Divisibility
8. Trialibility
9. Credibility

Characteristics of an organization which affect the probability of innovation within it are [N.I.M.H., 1972, pp. 8-14]:

1. Organizational Climate:

   a. Communication.
   b. Administrative and colleague support.
   c. Participation in decision making.
   d. Staff morale.
   e. Time.

2. Organizational Goals.

3. Organizational Structure.

4. Organizational Size.

5. Organization Affluence and Capacity.

6. Characteristics of Organization Leadership.

7. Professionalism of Staff.

8. Relationship of Organization to Social Environment.

9. Other Factors (additional factors appearing in the literature related to innovating organizations):

   a. Organizational, or staff cohesiveness.
   b. Physical and social distance between members and sub-unit.
   c. Enduring patterns of satisfying social relationship among staff.
   d. Tenure of the chief administrator is inversely proportioned to the number of innovations in an organization.
   e. Antecedent innovations - Organizations in which there have been changes are more open to further change.
   f. Organizational inertia (must be overcome).
   g. Strong vested interest in preserving status quo inhibits introduction of change (must be overcome).

Jolly [1975, pp. 148-166] made a study of the Technology Transfer capability of eleven organizations with the objective of attempting to measure the diffenences in performance between organizations that accept technology movement and utilization simply as a diffusion process as contrasted to organizations that make a purposive, conscious effort to

communicate and utilize knowledge. A modified Delphi process was utilized to arrive at the nine factors shown in Figure 4:

1. Documentation
2. Distribution
3. Organization
4. Project Selection
5. Willingness
6. Capacity of Receiver
7. Linkers
8. Credibility
9. Rewards

Several of the factors are similar to those appearing in the Distillation. However, the most important one added is the "linker". The combination of the two "summaries" essentially encompass most of the salient factors affecting innovation.

A questionnaire instrument was developed and administered to professional employees of the eleven organizations. The data have not been completely analyzed but tend to lead to the feeling that it may be possible to identify organizations (using this technique) that are high and low performers in terms of Technology Transfer. From this, one might postulate that certain actions could be taken to change the behavior of individuals within the organization so the organization would become more efficient.

VIII. THE IMPORTANCE OF INFORMATION CHANNELS IN TECHNOLOGY TRANSFER

There are many ways to acquire information/knowledge leading to adoption of "new" technology. It appears that personal contact is the most effective way of transferring knowledge. It is questionable as to the relative value of internal versus external sources. Additionally, there is evidence that engineers do not utilize the correct sources for information. This section will discuss literature that supports these points.

Cetron [1974, p. 2] states that there are many channels through which technology can be transferred and lists 13. However, only eight would apply to a T & E facility. They are:

1. Selling or purchasing end items.
2. Industrial shows, exhibits, and trade fairs.
3. Selling or purchasing components.
4. Technical meetings.
5. Patents.
6. Open literature.
7. Immigration/emigration.
8. Technical literature.

He concludes with, "Despite these many channels, the fact is that the most effective and efficient transfer of technology is the long-term transfer accomplished through the transfer of people".

Allen [1966, pp. 1-28] analyzed 19 projects to determine the eventual impact which various information gathering practices had upon the quality of research being performed. The eight channels investigated are listed in Table III. Total frequency counts for messages received and accepted from each of the eight channels are shown on Table IV and Figure 6. Allen finds that customer and vendors are most used by engineers and that the literature is the least used channel. The most important aspect of his data, lies in the fact that the channels used with the greatest frequency are not the ones which provide the greatest number of acceptable ideas.

Analysis of relative performance shows the three channels which might be considered to involve "expert" sources to have the highest performance. These three channels, technical staff, company research, and external sources all produce very high acceptance rates among engineers.

The principal conclusions of the study were:

1. There is a serious misalignment between the quality of the ideas generated through the channels studied, and the frequency with which these channels are used by engineers.

2. Literature is not greatly used, and is mediocore at best in its performance.

3. Better performing groups rely more than the poorer performers upon sources with the laboratory (the technical staff, and other company research programs) as contrasted with sources outside the lab.

TABLE III

TYPICAL INFORMATION CHANNELS CONSIDERED IN THE STUDY

literature:	books, professional, technical and trade journals and other publicly accessible written material.
vendors:	representatives of, or documentation generated by suppliers or potential suppliers of design components.
customer:	representatives of, or documentation generated by the government agency for which the project is performed.
external sources:	sources outside the laboratory which do not fall into any of the above three categories. These include paid and unpaid consultants and representatives of government agencies other than the customer agency.
technical staff:	engineers and scientists in the laboratory who are not assigned directly to the project being considered.
company research:	any other project performed previously or simultaneously in the lab regardless of its source of funding.
personal experience:	ideas which were used previously by the engineer for similar problems and are recalled directly from memory.
analysis and experimentation:	ideas which are the result of an engineering analysis, test or experiment with no immediate input of information from any other source.

TABLE IV

MESSAGES RECEIVED AND MESSAGES ACCEPTED BY R & D SCIENTISTS AND ENGINEERS AS A FUNCTION OF INFORMATION CHANNEL

Channel	Messages Received	Messages Accepted	Acceptance Ratio
literature			
scientists	18	6	0.33
engineers	53	21	0.40
external sources			
scientists	5	5	1.00
engineers	67	32	0.48
vendors			
scientists	0	0	---
engineers	101	33	0.33
customer			
scientists	0	0	---
engineers	132	41	0.31
technical staff			
scientists	1	0	0
engineers	44	24	0.55
company research			
scientists	1	0	0
engineers	37	20	0.54
analysis and experimentation			
scientists	3	1	0.33
engineers	216	72	0.33
personal experience			
scientists	7	4	0.52
engineers	56	17	0.30
unknown	75	6	---

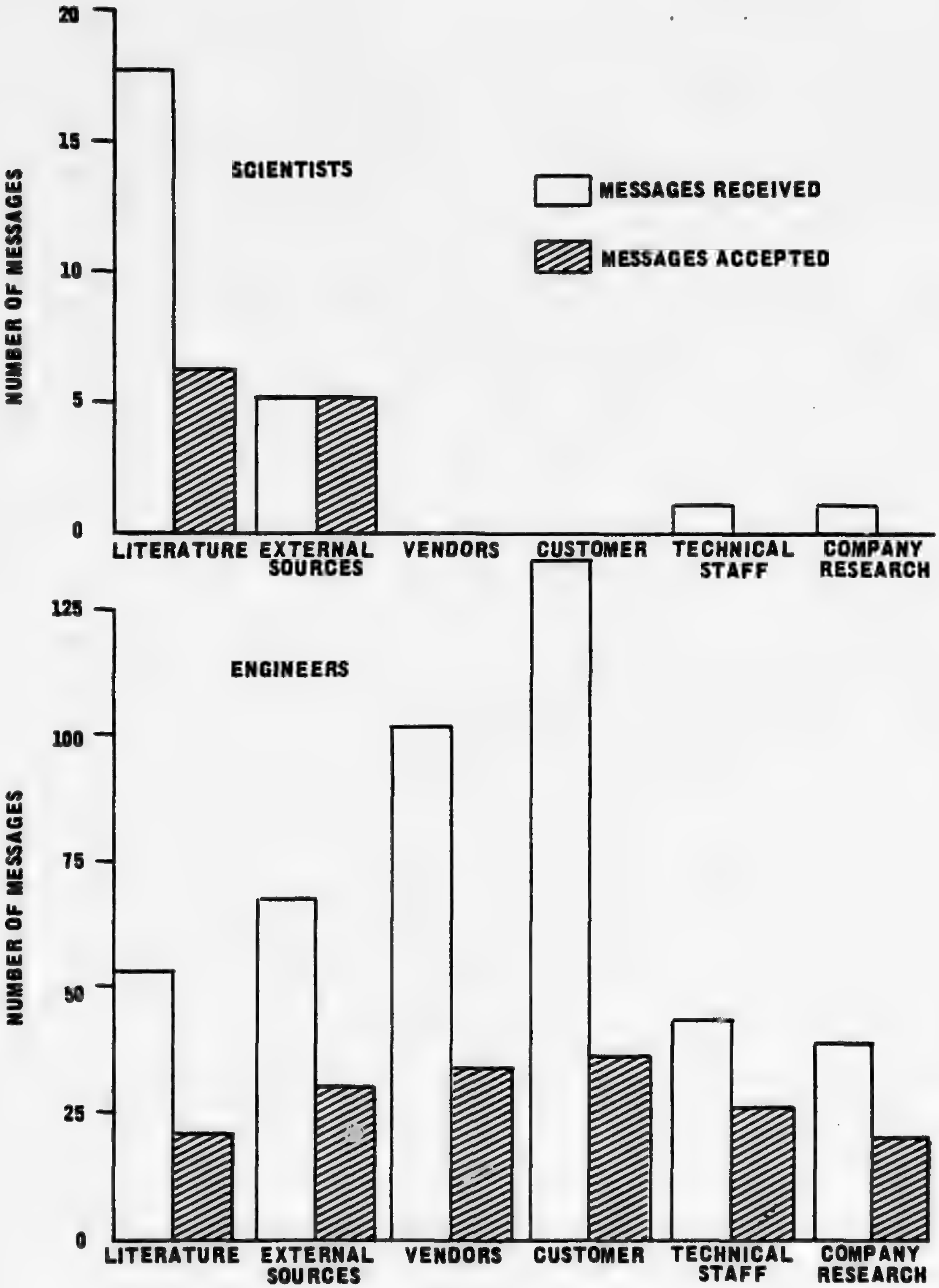


FIGURE 6

INFORMATION CHANNEL
MESSAGES RECEIVED AND MESSAGES ACCEPTED BY R&D SCIENTISTS AND ENGINEERS AS A FUNCTION OF INFORMATION CHANNEL

4. A mismatch in information coding schemes appears to be responsible for the ineffectiveness of communication across the organizational boundary. The possible existence of key individuals (technological gatekeepers) shows promise of providing a means of surmounting this organizational boundary impedance.

Schon also feels that the principal source of major technical change is innovation by invasion [Schon, 1964, pp.52-60].

Goldhar, Bragaw, and Schwartz [Golhar, 1976, pp. 51-56] reported on channels and sources of information having greatest value as a stimilus to innovation. Their study was based on an analysis of a questionnaire completed by winners of the IR-100 award. Table V lists the channels of information and Table VI lists the sources of information. Company colleagues, company conferences and bright ideas, all in-house channels, had the greatest value.

The information sources of greatest value are predominately internal and transmitted mostly by informal channels. The unimportance of technical supervisors and company management in general, and the innovator's heavy reliance upon his own knowledge, experience, and creative abilities (Table VI) in the innovative process, are two factors worthy of special note.

Gartner and Naiman, referring to a study by Allen and Reilly, state that "Nearly all of the information for innovation came through personal contact" [Gartner, 1976, p. 26].

TABLE V

CHANNELS OF INFORMATION REPORTED AS HAVING "GREATEST VALUE" AS A STIMULUS TO INNOVATION

Channel	% Reported as "Greatest Value"
Information Discussion with Technical Colleagues with the Firm (I)	41
Informal Discussion with Non-Technical Colleagues within the FIRM (I)	4
Informal Discussion with Technical Colleagues Outside Innovator's Firm (I)	8
Conferences at Company or Division Headquarters (F)	12
Written Memoranda (F)	1
Academic Courses (F)	1
Attendance at a Professional Meeting (F)	1
Bright Idea - No Outside Channel (I)	18
Professional Journal in Innovator's Field (F)	7
Technical Book (F)	2
Professional Journal Outside Innovator's Field (F)	1

Note: I = informal channel; F = formal channel.

TABLE VI

SOURCES OF INFORMATION REPORTED AS HAVING "GREATEST STIMULUS" AS A STIMULUS TO INNOVATION

Source	% Times Reported "Greatest Stimulus"
Innovator's Prior Experience and Training (I)	48
Technical Colleague within your Firm (I)	12
Technical Supervisor (I)	1
Client or Customer (I)	4
Technical Book (E)	0
Technical Article (E)	6
Technical Talk or Conference (E)	1
Company Production Group (I)	1
Company Marketing Group (I)	4
Non-Technical Book or Article (E)	0
Non-Technical Supervisor (I)	1
Non-Technical Colleagues in Innovator's Firm (I)	1
Firm's Long-Range Planning Group (I)	1
Competitor's Product (E)	2
Technical Colleague not in Innovator's Firm (E)	4
New Knowledge about Innovator's Technical Discipline (E)	8
Company Executive (I)	1
Patents (E)	1

Note: I = internal source; E = external source.

The implications for a T & E organization manager are that he should encourage mobility within the organization, and place heavy reliance upon personal contact. However, the mere fact that certain channels have been more effective in the past is not sufficient reason to ignore the other channels. Possibly, an educational process directed toward utilization of computerized retrieval systems would significantly increase the "value" of that channel. Additionally, who knows how many innovative ideas are reinforced or generated at technical conferences and symposia? I suspect many.

IX. CHARACTERISTICS OF INNOVATORS/ADOPTERS

In any social system it is desireable to locate the innovators/adopters. They are the ones that are instrumental in the success of an innovation. Essentially, they have the behavioral characteristics that are required to achieve Technology Transfer.

Goldhar, Bragaw, and Schwartz [1976, pp. 53-55] analyzed the characteristics of innovators from data acquired from the questionnaire returned by the IR-100 winners. The sample was skewed by a high number of Ph.D.'s and older respondents in the population so the data must be considered accordingly. The innovators reported high levels of automony. The innovators also reported that they prefer work with long-term gains, great challenge, and the development of basic new knowledge. In general the innovators also supported the contention that the innovative process is continuous and cumulative.

Cox [1976, p. 30] discussed the main characteristics of entrepreneurs and feels that they are usually persons who have the reputation of getting things done. They know how a technological idea is created, evolved, financed, marketed, and even managed.

> "They are risk-takers who dare to be different. They are impatient with time, extremely confident of their own talent, and respectfully skeptical of what is known. Their immediate supervisor often says they are hard to handle, too outspoken, and rather abrasive. But to the people who report to them, the entrepreneur has a

sensitivity and an understanding of what motivates people he contacts in order to get the job done. In brief, entrepreneurs are the catalytic agents that bring science and technology into the market-place by their enthusiasm, courage, and persuasive tenacity."

Schein [1974, pp. 346-347] makes five hypotheses about the processes of organizational influences on the individual (socialization) and individual influences on the organization (innovation). Three pertain to Technology Transfer/Innovation:

Hypothesis 1: Organizational socialization will occur primarily in connection with the passage through hierarchial and inclusion boundaries.

Hypothesis 2: Innovation, or the individual's influence on the organization, will occur in the middle of a given stage of the career, at a maximum distance from boundary passage.

Hypothesis 3: In general, the process of socialization will be more prevalent in the early stages of a career and the process of innovation late in the career, but both processes occur at all stages.

Figure 7 diagrams the relationships mentioned in the three above hypotheses. "If it is a correct assumption that genuinely creative innovative behavior can occur only when the person is reasonably secure in his position, this is tantamount to saying that he has to have a certain amount of acceptance and centrality to innovate."

The import of these hypotheses is that, a manager cannot expect innovative behavior to occur until a new hire or transfer has been in the organization long enough to be accepted and feel secure.

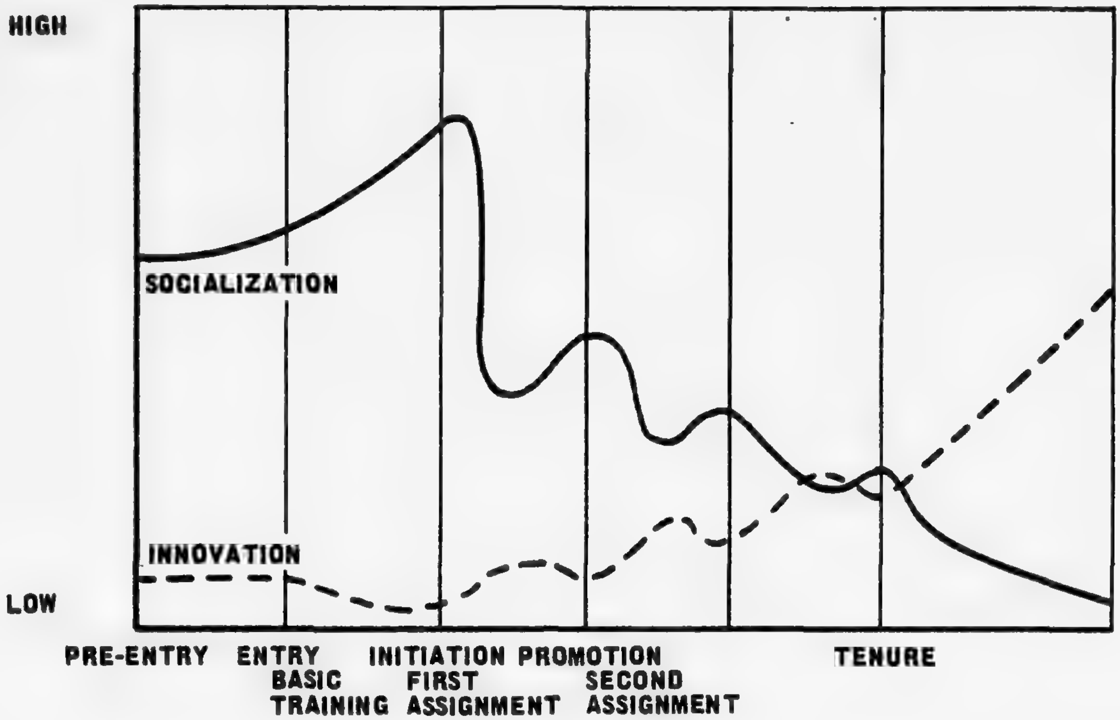


FIGURE 7

SOCIALIZATION AND INNOVATION DURING THE STAGES OF THE CAREER

The N.I.M.H. Distillation [1972, p. 173] lists the following personal attitudes for innovation, and diffusion of teaching practices.

1. Seeks new ways.

2. Seeks peer and consultant help.

3. Always open to adopting and modifying practices.

4. Desires public rewards for professional growth as opposed to monetary rewards.

5. Sees groups as endemic and relevant for academic learning.

6. Optimistic.

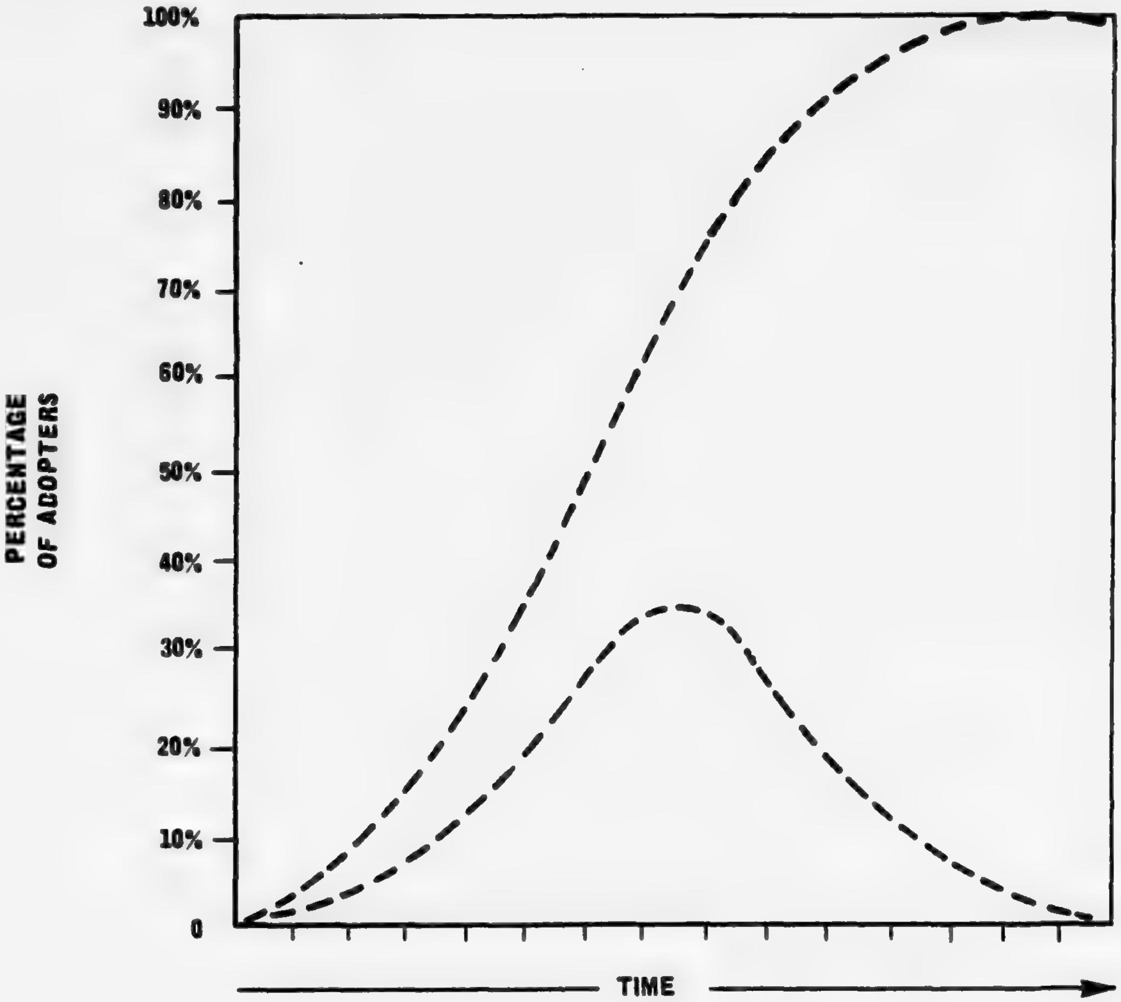
7. Tests ideas slowly.

8. Suits and changes practice to fit one's own style.

Testing ideas slowly does not mean innovating slowly. What it means is the innovator is not in a hurry to select the first solution he finds. He explores all alternatives.

Titles of adopter categories are about as numerous as researchers themselves. One method of adopter categorization, based upon the S-shaped curve of adoption, has gained a dominant position in recent years. If the cumulative number of adopters is plotted, it results in an S-shaped curve. If a curve is plotted as a percentage of adopters vs. frequency, the normal bell shape curve results, Figure 8, [Rogers, 1971, pp. 177-178].

Innovativeness is a relative dimension in that an individual has more or less of it than another individual. Rogers and Shoemaker feel that a measure of innovativeness



BOTH OF THESE CURVES ARE FOR THE SAME DATA, THE ADOPTION OF AN INNOVATION OVER TIME. BUT THE BELL-SHAPED CURVE SHOWS THESE DATA IN TERMS OF THE NUMBER OF INDIVIDUALS ADOPTING EACH YEAR, WHEREAS THE S-SHAPED CURVE SHOWS THESE DATA ON A CUMULATIVE BASIS.

FIGURE 8

THE BELL-SHAPED FREQUENCY CURVE AND THE S-SHAPED CUMULATIVE CURVE FOR AN ADOPTER DISTRIBUTION

is the degree to which an individual is relatively earlier in adopting new ideas than other members of his social system. They list five adopter categories based upon the degree of innovativeness:

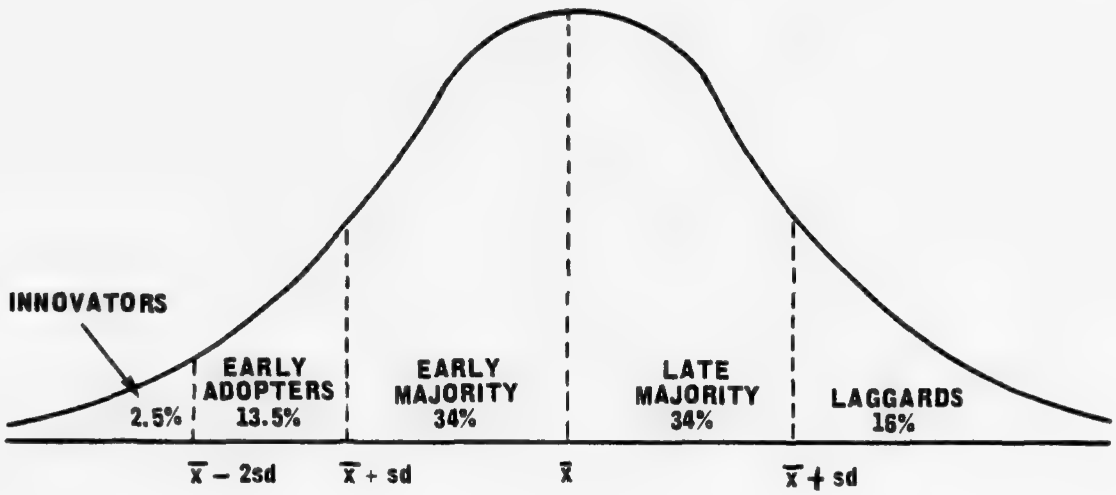
1. Innovator (venturesome).
2. Early adopters (respectful).
3. Early majority (deliberate).
4. Late majority (skeptical).
5. Laggards (traditional).

Figure 9 shows the normal frequency distribution divided into the five adopter categories.

Rogers and Shoemaker make 32 generalizations, from 3000 findings, under the headings of:

1. Socioeconomic status.
2. Personality variables.
3. Communication behavior.

The generalizations are presented as Exhibit 1, Appendix D. Most of the generalized variables are positively related to innovativeness. However, a few are negatively related, Figure 10. Opinion leadership seems greatest for early adopters. The important differences among the categories suggest that change agents or managers might utilize different strategies of change for each category of adopter.



THE INNOVATIVENESS DIMENSION, AS MEASURED BY THE TIME AT WHICH AN INDIVIDUAL ADOPTS AN INNOVATION OR INNOVATIONS IS CONTINUOUS. HOWEVER, THIS VARIABLE MAY BE PARTITIONED INTO FIVE ADOPTER CATEGORIES BY LAYING OFF STANDARD DEVIATIONS FROM THE AVERAGE TIME OF ADOPTION.

FIGURE 9

ADOPTER CATEGORIZATION ON THE BASIS OF INNOVATIVENESS

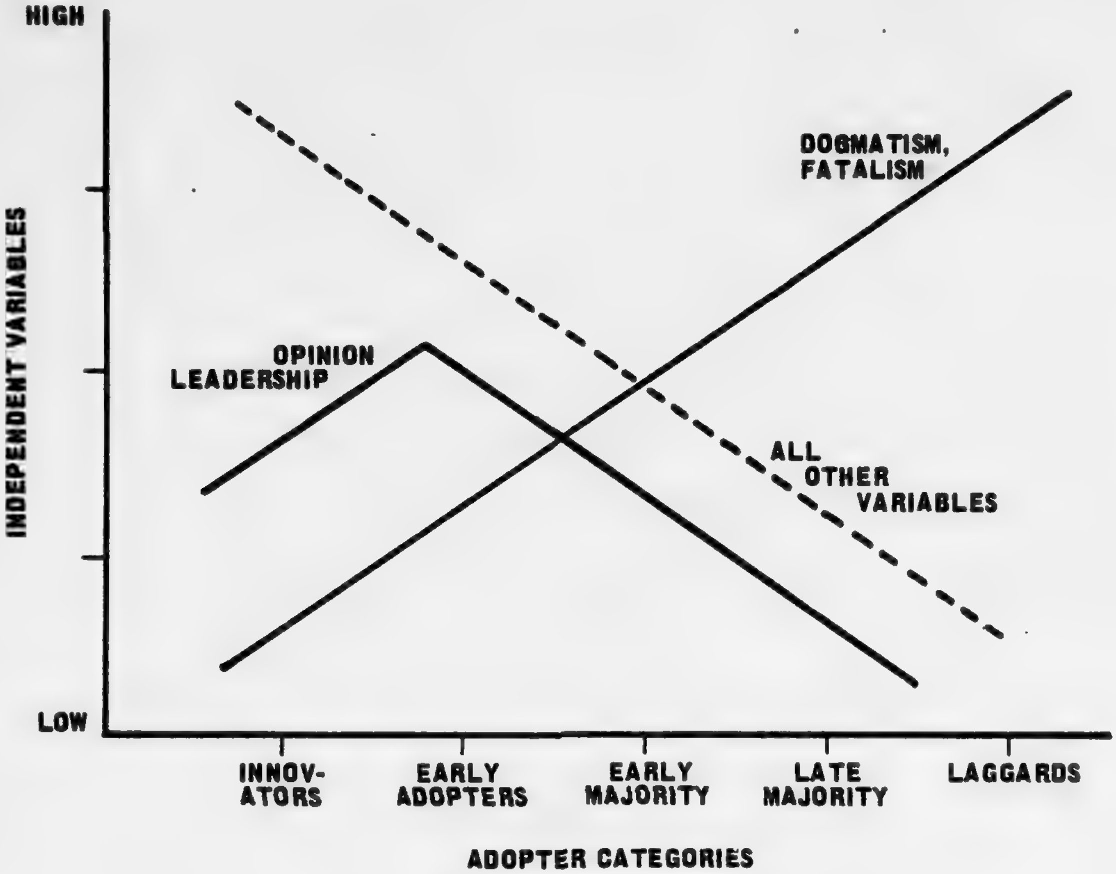


FIGURE 10

ABSTRACTION OF GENERAL DIRECTION OF RELATIONSHIP OF INDEPENDENT VARIABLES WITH INNOVATIVENESS

X. LINKER CHARACTERISTICS

Linkers are important in the process of Technology Transfer. They are not necessary to the process, but they have been found to play a large part in many innovations. They are known by many names, but are closely associated with the innovator/adopter characteristics discussed in the previous section. This section discusses the characteristics and identification of linkers.

Figure 4, the Predictive Model of Technology Transfer, is composed of nine factors that make-up the linking mechanism necessary to achieve effective Technology Transfer. The LINK factor (Informal linkers in the receiving organization) has been the subject of several studies [Creighton, 1972, Claassen, 1973, and Jolly, 1974]. Their work relates to the presence and effects of informal linkers in the receiving organization. The user's linking role is "taking initiative on one's own behalf to seek out scientific knowledge and derive useful learning therefrom" [Havelock, 1973, p. 7-4a]. Claassen's definition of a linker is "an individual who through his own initiation seeks out scientific knowledge, is an early knower of innovation, and acts as an intermediary between the source of knowledge and the individual's organization who put it into use" [Claassen, 1973, p. 8]. The linker concept as utilized by Creighton, Jolly, Denning and Claassen is that, a linker functioning within the user's organization would exhibit identifying

traits and characteristics similar to the gatekeeper, opinion leader, innovator, and early knower of an innovator. Although the term linker implies a third party between the source and user of knowledge, he need not be part of an independent organization.

The objective of research by Creighton, Jolly and Denning [1972] was to identify the individuals functioning as linkers within the Naval Civil Engineering Corps. They accomplished this by administering a Professional Preference Census (PPC) questionnaire and validating it with an Oral Linker Census (OLC) questionnaire administered to the linkers identified by the PPC. Much of the development of the PPC was based on the generalizations made by Rogers and Shoemaker presented in Section IX. The responses from 1128 Naval Civil Engineering Officers were examined in this study.

A second study was made by Claassen [1973]. He analyzed the responses of 1598 Government service Civil Engineers and related technical personnel. Both studies successfully identified linkers and stabilizers in the population sample investigated. The PPCs and OLC can be found in Appendix E as Exhibit 1, 2, and 3 respectively.

Jolly and Creighton [1974] further analyzed the data from the two studies to determine if it were possible to qualify as a linker or a stabilizer through different combinations of behavioral performance. Their hypothesis was "The distribution of the linker-stabilizer behavior characteristic has a general base in terms of technically trained personnel and is

not unique to a select population." Their analysis revealed that it is reasonable, accepting the limitation of the research, to accept the hypothesis as true.

Taylor [1976] made a study of the technological gatekeepers at a large military in-house research and development laboratory. In order to try to arrive at a demographic profile of the gatekeeper, 184 military and civilian engineers were analyzed. He found that "Gatekeepers tend to be older, have a higher level of education, have more technical experience, have been at the laboratory and in the work group longer, and are predominately civilians."

His analysis of spatial relationships demonstrated that the probability of communication declines as the distance between communicators is increased. The magnitude of the decline is dependent upon nuisance factors such as partitions and desks as well as gatekeeper location. Gatekeeper effectiveness does not appear to be diminished because of location or distance from colleagues.

However, Creighton says that distance between communicators ceases to be a barrier when the communicators trust the telephone and cease to pay attention to administrative barriers to the use of long distance lines. It is his experience that distance can be a facilitator. At certain times of the day, morning on the west coast and evening on the east coast, few people are at their desks except those across the country. At these times, the information sources are available by phone across the country, but not nearby.

Gartner & Naiman /Gartner, 1976, p. 27/ feel that individuals can be trained to become good Technology Transfer change agents. To be successful, they would have to possess the following characteristics:

1. They are good listeners, emphatic and accepting, able to generate enthusiasm. Being optimistic and persistent, they tend to encourage their peers. They are ready to accept inputs from others, are critical but trustful.

2. Have depth in at least one discipline; some have made substantial contributions to two or even three disciplines.

3. They have a wide range of interests, and are regular readers of journals.

4. They are oriented toward problem solving, and are quick to abandon an old specialty if a new one seems more promising.

Other characteristics that contribute to success but are not as essential as the preceding ones include:

1. They have taken an unconventional set of courses in college.

2. They have realized early that a range of disciplines is required to solve problems in science or technology.

3. They seek involvement in diverse kinds of problems in science or technology.

4. They have multiple connections with various societies.

5. They have aspirations different from those of the majority of professionals. They try to understand nature.

6. They show intense interest in whatever area they are investigating at the moment.

7. They are generally good salesmen of ideas and projects with an easy perception of the needs of others.

The studies based on the linker concept have demonstrated that linkers can be identified with a high degree of probability, by administering the PPC to the individuals in an organization. Once these linkers are identified, they can be utilized to aid the transfer of knowledge by being opinion leaders, gatekeepers, innovators, etc.. Management should, therefore, try to identify the linkers in their organizations and insure that one is located in an area where change is contemplated.

XI. CREATIVE TECHNIQUES

Previous sections have alluded to the requirement to be creative in the innovation process.

> "The starting point of the innovation process is to tap the full power of man's innovativeness; that is to develop the creative aspects of the man - the use of imagination." /Miller, 1970, p. 86/.

Creative thinking is no longer thought to be a function of I.Q. or to be restricted to people with those inborn capabilities. Watson feels that there are two kinds of creativity; primary and secondary. Primary creativity is the unconscious process of insight and inspiration, seeing things in a fresh way. Secondary creativity is deliberate, conscious, planned problem solving. Few people are blessed with primary creativity. However, almost all can develop secondary creativity. All people are creative to some extent. While tests are not yet completely capable of identifying creative people, the following traits are often cited as being associated with creative persons /Watson, 1975, pp. 14-15/.

1. He has an open mind.

2. He is not a conformist. He values his own self-respect more than the respect others may have for him.

3. He is aggressive, self-assertive, and quick with suggestions.

4. He works by his own timetable.

5. He works hard for long periods of time. Instead of saying there isn't a solution to my problem, he is more likely to say that he is going about solving the problem in the wrong way.

6. He is willing and able to consider and express irrational ideas and impulses.

7. He is not bothered by working on problems which may not have clear-cut and unambiguous answers.

8. He is not a rigid rule-follower.

9. He likes to toy with new ideas even if they turn out later to be a total waste of time.

10. He is more impressed with what he doesn't know than with what he does know.

11. He doesn't make black and white distinctions.

12. He thirsts for new and unusual experiences.

13. He wants and likes freedom to explore new things and ideas on his own.

14. He doesn't take things too seriously, and likely has a sense of humor.

15. He is above average in intelligence.

Miller feels that there are five characteristics present in persons of high creativity [Miller, 1970, pp. 228-229].

1. Sensitivity - ability to see things as they really are.

2. Fluency - ability to come up with a large number of ideas in a short time frame.

3. Flexibility - ability to come up with a great variety of ideas.

4. Originality - a creative person is by habit and mind freer of fears and inhibitions.

5. Imagineering - letting imagination soar and then engineering down to earth.

Miller [1970, p. 90] lists four requirements for creative decision making:

1. Extended effort.
2. Suspended judgment.
3. Large volume of ideas.
4. Incubation of ideas.

Edwards [1975, p. 15] visualizes the following imaginative formula for creative behavior:

CB = I x D x E x A, where:

I = Imagination	D = Data or knowledge
E = Evaluation	A = Action or implementation

He states that considerable time should be spent with the systematic approach to problem solving which consists of:

1. Describing the problem.
2. Finding the facts.
3. Defining the problem.
4. Thinking up alternatives.
5. Deciding what action to take.
6. Taking action.

Miller gives five steps in the creative decision-making process:

1. Goal or problem selection.

2. Generating ideas.

3. Using creativity to select evaluation criteria.

4. Selection of ideas as alternative solutions to a problem.

5. Determining the innovation potential of an idea.

Edwards [1975, p. 17] suggests that persons developing their creativity should learn to alternate in:

1. Thinking/judging (learning to defer judgment).

2. Individual/team or group effort.

3. Involvement/detachment or relaxation, inviting incubation (incubation may be planned by working alternately on creative projects).

4. Intensity/duration of effort.

5. Point of view (actively seek ways to change it, to restructure perceptions and think beyond the obvious or familiar).

Miller gives seven "spurs" which can assist in developing individual creativity [1970, pp. 231-235].

1. Make up a list of problems that need to be solved. Refer to this list daily, revise the list frequently.

2. We all produce better when we have a definite goal. A quota to achieve by a certain time sparks greater effort.

3. Set a date when the problem must be solved. Deadlines intensify emotional power.

4. Make it a part of the daily schedule to talk to people who can give ideas for the solution of your problems.

5. Set aside a definite time each day for creative thinking.

6. Set a place for creative thinking but remember that good ideas come almost anyplace.

7. Keep a notebook handy and use it.

Some of the more prominent creative thinking techniques are presented in Exhibit 1, Appendix F.

From the information presented above, it is postulated that creative thinking and action in an organization can be improved by management effort to:

1. Provide the environment for creative thinking.

2. Provide training in the principle and techniques of creative thinking and decision making.

3. Utilize the systematic approach to creative problem solving.

However, it must be remembered that creativity is not more necessary to succeed at in innovation than any other characteristic. What is important is that all four of the following attributes are utilized:

1. Creative ability.

2. Skill in evaluating ideas generated by creative thinking.

3. The ability to finalize the proposal for innovation.

4. The ability to prepare a program for implementing the innovation that overcomes the obstacles to the change.

XII. THE USE OF TECHNOLOGY TRANSFER TECHNIQUES TO REDUCE OBSOLESCENCE

Technological change has been occurring at an incredible rate and has created problems of obsolescence among engineers. A fairly widespread approach to the problem by organizations has been to leave the burdens of obsolescence to the individual. As requirements change, new employees are hired and other employees are fired. This cannot be easily accomplished in the Department of Defense because personnel ceilings are being cut and laying off of personnel is very difficult. Consequently, the percentage of older employees is increasing. An alternate policy is to provide time, funding, and training to assist employees to keep current in their field.

Training and education is one form of Technology Transfer. Technical skills can be up-dated by taking technical college courses, selected technician type courses related to state-of-the-art developments, and specialized in-house courses tailored for organization needs.

A study by Kaufman [1975, pp. 20-23] shows little doubt that among engineers, the most important objective in obtaining additional education or training is to keep from becoming obsolete. Table VII shows this relationship. However, the study also found that course taking objectives are more oriented toward future career development rather than present job needs. Table VII also indicates that only about one out

of three engineers feels that obtaining an advanced degree is an important objective in continuing education.

TABLE VII

IMPORTANCE OF OBJECTIVES IN GETTING ADDITIONAL EDUCATION OR TRAINING AMONG 4400 DEVELOPMENT ENGINEERS

Objective	% Saying of Utmost Importance
To keep from becoming obsolete	64.3
To prepare myself for increased responsibility	62.8
To perform my present assignment better	44.8
To remedy deficiencies in my initial training	38.8
To obtain an advanced degree	34.2
To enable me to become an authority in my field of specialty	34.1
Because my manager expects his people to take additional oourse work	6.6

Kaufman states that those who engage primarily in in-house courses tend to have received few promotions and report that they have made only modest contributions to their organization. Those with the strongest engineering ability participate to a greater extent in graduate courses, whereas those weak in these abilities tend to take the most in-house courses. It is found that those engineers who are the poorest performers initially, tend to take more in-house courses subsequently.

Graduate courses are clearly more effective in keeping engineers from becoming obsolete than are in-company courses. However, the usefulness of graduate courses for updating all professionals may be limited, since they are avoided by those

who have the greatest predisposition toward obsolescence. In-company courses have the potential to contribute to the updating of engineers who are more obsolescence prone. However, there generally has been a lack of management efforts toward creating in-company courses to meet these needs.

Miller suggests several tools to aid in the obsolescence solution [1975, pp. 16-17].

1. Education.

2. Job rotation.

3. Sabbaticals.

4. Job re-design.

5. Technical library.

6. Support of professional society activity.

7. Change method of management measurement. (Do managers enhance value of employee?)

8. Management support of above.

9. Focus on long-range goals.

The import of the obsolescence problem to the T & E manager is that his personnel will probably exhibit more of its characteristics than his counterparts in private industry. He must find some way of determining the magnitude of his problem and take action to correct it. Ways of alleviating the problem are:

1. Devising in-house courses that relate directly toward areas of technological improvement that are needed.

2. Encourage/direct personnel to take the courses.

3. Continue encouragement of related graduate and undergraduate level of technical courses.

4. Provide an environment so the skills/knowledge can be utilized.

5. Encourage an atmosphere of positive change and technological improvement.

XIII. CONCLUSIONS

Because of today's rapidly changing technological environment in the Test and Evaluation community, more complex, and state-of-the-art weapons systems and components are required to be tested. Improved test techniques and capabilities are required to meet this demand. One tool for improving technical capability is Technology Transfer.

Technology Transfer is primarily a people process. It is the nature of the majority of human beings to resist change. Methods must be utilized to create a positive environment for change, thereby reducing the resistance to change.

A search of literature relating to Technology Transfer, innovation, and creativity has supported a Paradigm for utilizing Technology Transfer concepts as an aid for engineering management in a Test and Evaluation organization.

Chief Engineers at the Naval Air Test Center are middle management engineers and are responsible for the technical output of their Directorate. To achieve Technology Transfer the Chief Engineers should either accomplish or ensure that the following actions/procedures are accomplished:

1. Communicate the need to innovate to the Branch Heads and Branch Chief Engineers. Ensure that they know the management emphasis on innovation, creativity, and Technology Transfer.

2. Analyze the background of the Chief Engineers, Branch Heads, and section Heads to determine the amount of training each has had relative to basic management, the innovative process, and creative thinking.

3. Establish a program to correct deficiencies in training.

4. Analyze past innovations within the Directorate to see who and how accomplished. Use the data for future planning of change.

5. Administer the Professional Preference Census Questionnaire (modified to suit) to professional and subprofessional personnel to determine the five categories of adopters/linkers to determine the possible linkers, potential linkers, middlemen, potential stabilizers, and stabilizers.

6. Gradually re-distribute the linkers and stabilizers to adjust inequalities within the organization. This may not be entirely possible because of disciplines and background.

7. Utilize the linkers for opinion leaders, gatekeepers, and early adopters.

8. Encourage supervisors to use appropriate motivation technique with their subordinates dependent upon the category identification determined by the P.P.C..

9. Reward innovative actions through ratings, in-house publications, awards by professional societies, releases to local news media, and allowing points toward promotion for innovative behavior (within regulations).

10. Encourage symposia attendence, face-to-face involvement with other T & E organizations (Navy, Army, Air Force), face-to-face involvement with R & D activities and the National Bureau of Standards, paper preparation and presentation.

11. Listen to feedback and adjust the program as appropriate.

12. Maintain complete communication at all times.

13. Determine what areas need innovation and change.

14. Establish a firm program with goals, resources, plans, and establish a schedule of implementation once an innovation is determined to be worthy of adoption.

15. Promulgate the philosophy that reasonable risk is acceptable and failure will not be punished except for those who don't try.

16. Gradually adjust talent to ensure that a diversity is available.

17. Create positive attitude for an image of change.

18. Encourage transfer of personnel.

19. Provide for long term planning of resource and facility requirements.

20. Encourage utilization of creative development techniques.

Technology Transfer is a tool and as such is no more important than any other management tool. Care should be taken to utilize it as such.

Finally, it should be remembered that opposition does not necessarily mean resistance to change. Some opposition may represent a sound and justifiable position.

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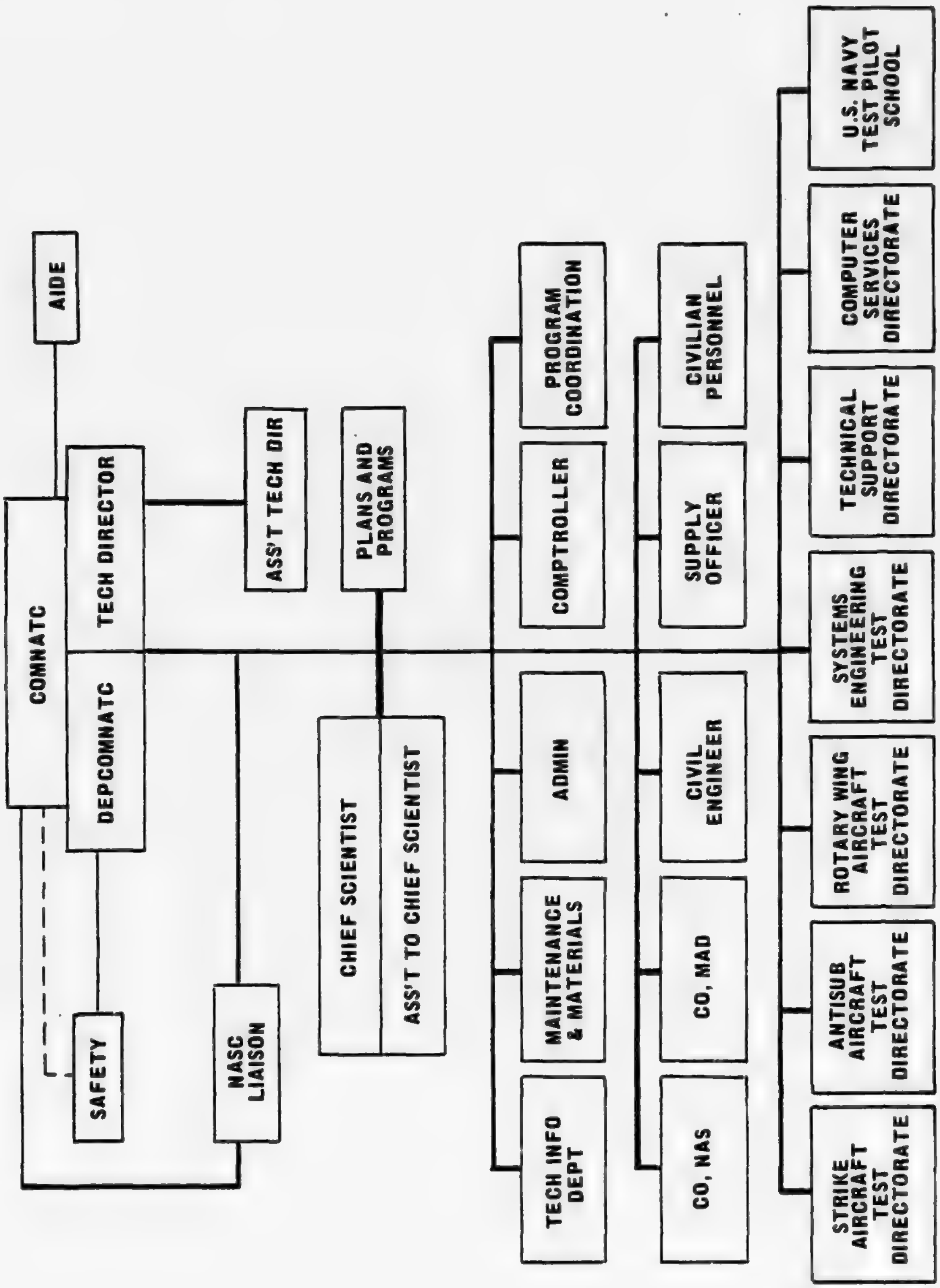


APPENDIX A

EXHIBIT 1

NATC ORGANIZATION

FUNCTIONAL STATEMENT
SYSTEMS ENGINEERING TEST DIRECTORATE

Manages, tests, and evaluates the service suitability, specification compliance and advance technology of aircraft ground support, electrical, aircrew, communication, identification, navigation aids, and armament systems. Tests and evaluations include monitor of contractor development efforts in cognizant functional areas; witness of contractor demonstrations, Navy Preliminary Evaluations, technical evaluations, BIS Trials, AIRTASKS in cognizant areas, and follow-on evaluations of modifications designed to correct deficiencies discovered as a result of fleet use or previous evaluations. Acts as Lead Naval Field Activity for aircraft electrical systems and Ground Support Equipments (GSE), including peculiar and common avionic support equipments, aircraft servicing and handling, engine trim, and weapon handling equipments. Develops, tests, and evaluates radar, tactical computers, and associated software common to strike, antisubmarine, and rotary wing aircraft. Tests and evaluates aircrew systems, including escape and survival systems, human interface and man-machine interface factors, and cockpit and environmental support systems. Performs electromagnetic propagation and compatibility tests and evaluations. Tests and evaluates aircraft weapon/store compatibility, including weapon release and control systems, store suspension equipments, and gun systems. Defines safe carriage and release envelopes for aircraft store combinations and ensures correctness and adequacy of External Stores Sections of aircraft Tactical Manuals. Responsible for all NAS/NATC ordnance and armory functions. Conducts independent research and exploratory development projects. Performs program manager functions as assigned by Commander, Naval Air Test Center.

Provides technical advice and assistance to NAVAIR, BIS, and other government agencies and contractors.

SUPPORTING TASKS

Manages, tests, and evaluates applicable aircraft systems, components, support systems, ordnance systems, electrical and electronic systems to determine compliance with specifications, contract guarantees, and service suitability requirements.

APPENDIX A

EXHIBIT 2

Functions as lead Navy laboratory for ground support equipment, airborne electrical components, and electromagnetic compatibility.

Manages and conducts tests and evaluations of ground support systems to determine suitability, compatibility, and supportability.

Conducts shipboard trials to determine operational suitability of cognizant systems with shipboard handling and servicing equipment.

Evaluates adequacy, arrangement, and technical aspects of aircraft interior and exterior lighting and lighting controls.

Conducts qualification tests to certify electrical components for the Navy "Qualified Products List".

Evaluates quality of workmanship and flight safety of electrical and electronic equipments and aircraft wiring installations after significant rework programs and on new aircraft acquisition programs.

Conducts ground tests and monitors flight tests of various electrical power generating and distribution systems.

Evaluates the aircrew/operational environment/man-machine interface of aircraft systems and aircraft mission systems.

Tests and evaluates aircrew equipment and escape and life support systems.

Evaluates downwash and aircraft acoustical characteristics.

Tests and evaluates mishap warning, search, and rescue systems.

Conducts electromagnetic compatibility (EMC) analysis and spectrum measurements on avionic equipments.

Conducts inspection, test, and evaluation of installed project instrumentation to determine its effect on safe aircraft operation.

Conducts aircraft store compatibility tests and evaluations of all aircraft armament items under the cognizance and technical control of NAVAIR.

Manages and analyzes all structural aspects of aircraft armament and store suspension systems.

Conducts safety analysis of applicable aircraft systems and support equipments.

Obtains through test and evaluation:

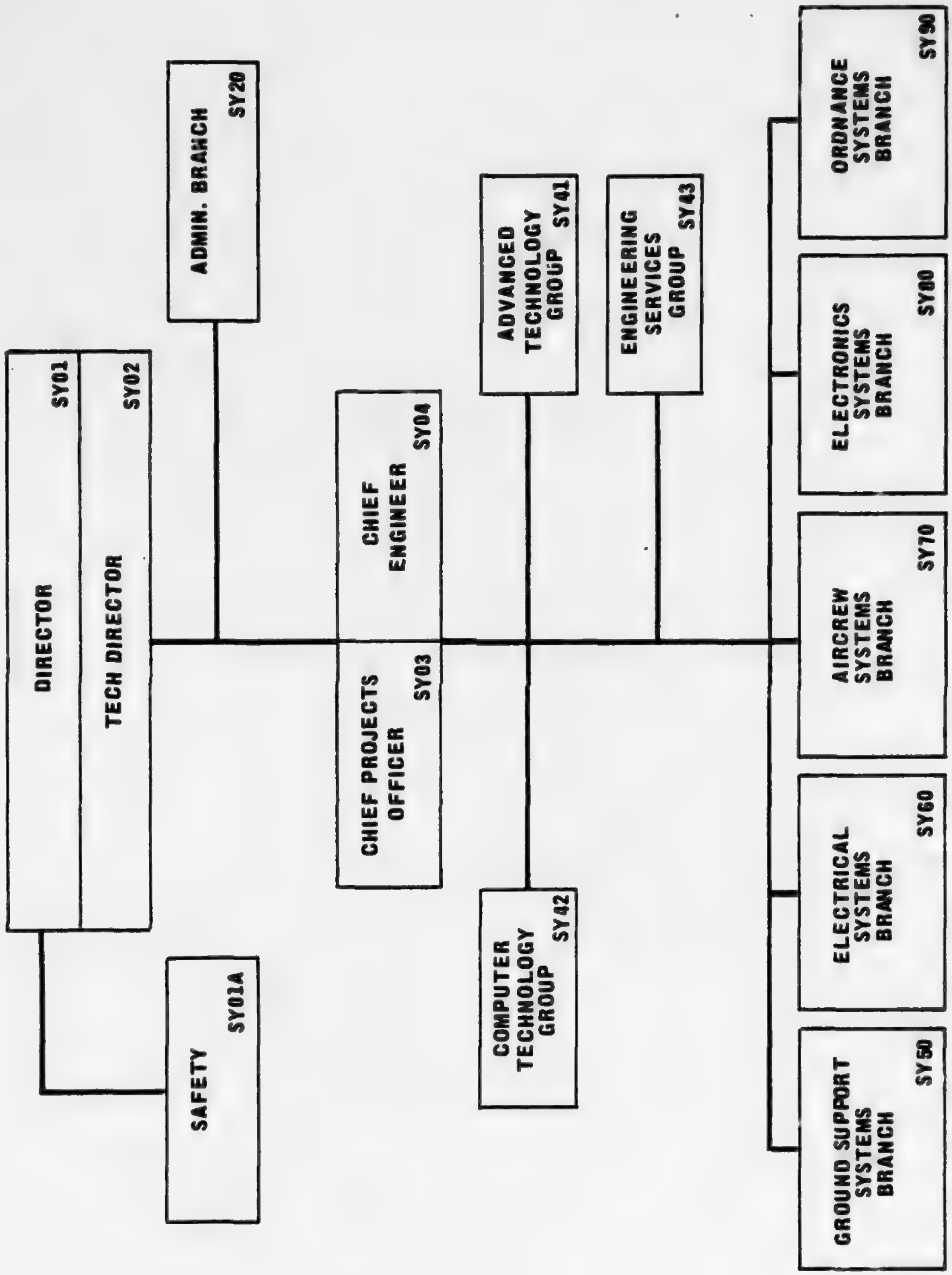
Information of significance to the advancement of applicable system and component design and operation.

Information supporting recommendations on design changes.

Information for use of other DT&E, OT&E, and fleet activities.

Develops and reviews appropriate design specifications for NAVAIR.

Investigates system and component problem areas encountered during DT&E, OT&E, and fleet use as directed by NAVAIR.



APPENDIX A

EXHIBIT 3

SYSTEMS ENGINEERING TEST DIRECTORATE

POSITION DESCRIPTION OF THE CHIEF ENGINEER OF THE SYSTEMS ENGINEER TEST DIRECTORATE

I. INTRODUCTION

This position is located in one of the Test Directorates of the Naval Air Test Center, Patuxent River, Maryland. The incumbent of this position serves as Chief Engineer and is subject to rotational assignment among the Strike Aircraft Test Directorate, the Anti-Submarine Aircraft Test Directorate, the Rotary Wing Aircraft Test Directorate, and the Systems Engineering Test Directorate and similar grade level positions.

II. MAJOR DUTIES AND RESPONSIBILITIES

1. The incumbent of this position assists the Director/Technical Director in the discharge of the Division's engineering functions. He provides a final technical review of test plans, reports and correspondence and assures the timely completion of assigned work units and provides continual input to the management of division funds. The incumbent is responsible for technical quality and adequacy of division output, for assigning projects and coordinating support of the various branches to division projects. He serves as a consultant on assigned systems and has a major voice in division decisions regarding the planning and utilization of manpower funding and facilities. The incumbent exercises technical supervision over the Branch Heads. He reviews and approves, amends or rejects the technical aspects of projects as assigned, other reports, and memoranda and correspondence.

2. The incumbent assigns projects to the appropriate branches and coordinates their efforts. He provides assistance and advice to the Branch Heads and Branch Chief Engineers during preliminary planning as required. He also administravely supervises the Technology Applications Group and the Reliability and Maintainability Branch. He provides liaison with other divisions. He plans new methods and techniques to meet the requirements of newly assigned projects, obtaining and coordinating input from the division branches and the Technology Applications Group.

APPENDIX A

EXHIBIT 4

3. He provides technical advice to the Board of Inspection and Survey, NASC, Naval Air Systems Command, T & E Coordinator, and other activities and contractors. He supervises research and development to improve test techniques, procedures, information gathering and data analysis methods. He is responsible for monitoring contractor development of aircraft and aircraft related systems components and related equipment, witnesses contractor demonstrations, Navy preliminary evaluation, technical evaluation prior to Board of Inspection Survey trials, and Board of Inspection trials in cognizant areas and follow-up evaluations of modifications designed to correct deficiencies discovered as a result of previous evaluations.

4. The incumbent of this position prepares estimates and requirements for use of manpower, funds and facilities to insure adequate support of present and future division requirements. He determines personnel requirements and recommends assignments or transfers of personnel to insure the most efficient organization. He recommends reorganization to meet changing needs and additional training to develop personnel capabilities.

5. The incumbent carries out EEO policies and communicates support of these policies to subordinates. Assures equality in determining qualifications, selections, assignments, training, promotion, details, discipline and awards to employees. Cooperates and participates fully in the development of an EEO Affirmative Action Plan and efforts regarding staffing, motivation and training to develop all employees. Ensures that minorities and women are considered for training opportunities and are also nominated/appointed to boards and committees. Coordinates efforts with EEO officials during the development and execution of policies affecting civilian personnel.

III. CONTROLS OVER THE POSITION

The incumbent's immediate supervisor is the Technical Director of the division to which he is assigned, a Supervisory General Engineer, GS-801-15. Performance is judged on the effectiveness in meeting mission objectives. Technical supervision received is nominal and consultative in nature and is usually limited to such matters as use of manpower, funding, and facilities to accomplish assignments. The incumbent has the status of an expert in both technical engineering matters and engineering management and his recommendations and decisions are generally accepted as technically sound although

final approval rests with the Technical Director and the Director. He is expected to solve both technical and administrative problems not having policy implications. He coordinates with and is on equal status with the Division's Chief Test Pilot.

IV. QUALIFICATION REQUIREMENTS OF THE WORK

The incumbent must have a sound professional knowledge of the field of engineering as represented by a Bachelor's of Science Degree in Engineering supported by progressively responsible experience in the practice and application of engineering principles particularly as they apply to test and evaluation functions associated with aircraft and aircraft related systems, systems components and instrumentation. He must have a thorough knowledge of the principles and techniques of management as applied to an engineering/scientific organization. A Master's Degree in engineering is preferred and highly desirable. He must be able to judge the feasibility and relative technical value of proposals of others who are themselves professionally mature engineers and scientists to anticipate major problems and to initiate corrective action when necessary. An understanding of the complete Test Center organization and mission is essential. The incumbent must have or be eligible for Top Secret clearance.

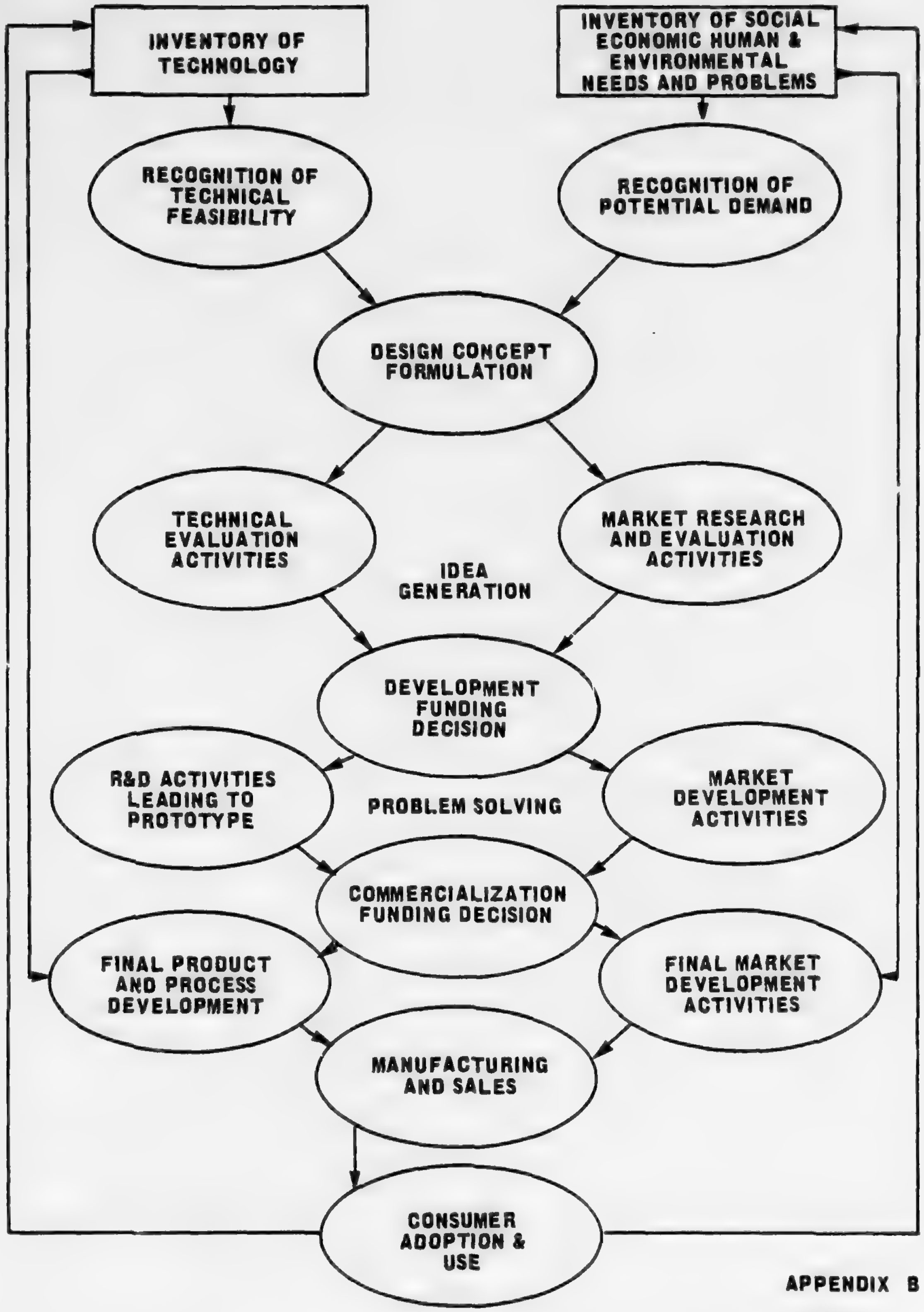
CHIEF ENGINEER'S RESPONSIBILITIES AS STATED IN NATC ORGANIZATION MANUAL

Responsible to the Technical Director for the technical supervision of the project engineering organization of the directorate. Functions as technical advisor to the Technical Director and the engineering staff of the directorate. Administers and supervises the technical aspects of the project engineering work, including the review and technical approval of the test programs, test plans, reports, and project correspondence originated by the directorate. Advises the Technical Director concerning the technical staffing of the organization and in matters relating to the recruitment, training, assignment, performance, and promotion of assigned civil service personnel.

In concert with the Chief Projects Officer, assigns projects to appropriate branches within the directorate. Co-administers the projects assigned and co-supervises project work. Establishes priorities for the accomplishment of work necessary to project support in accordance with relative importance of projects involved. Maintains liaison with the NATC Staff and other test directorates for mutual exchange of information and ideas, coordination and prompt prosecution of support requirements, and timely dissemination of contributory reports. Conducts liaison with NAVAIR and other Department of Defense activities as required to facilitate the conduct of projects.

APPENDIX A

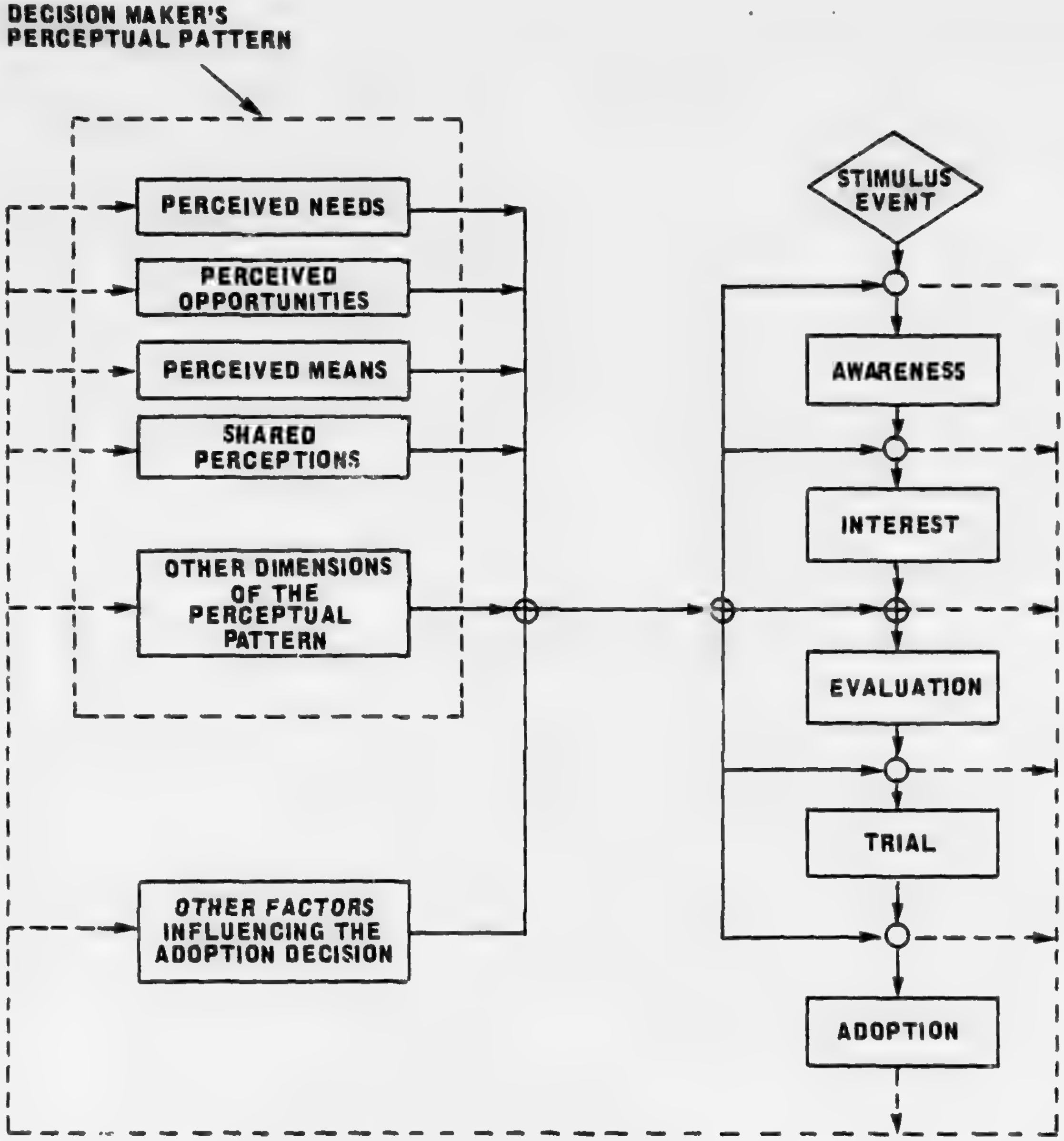
EXHIBIT 5



APPENDIX B

EXHIBIT 1

THE PROCESS OF TECHNOLOGICAL INNOVATION

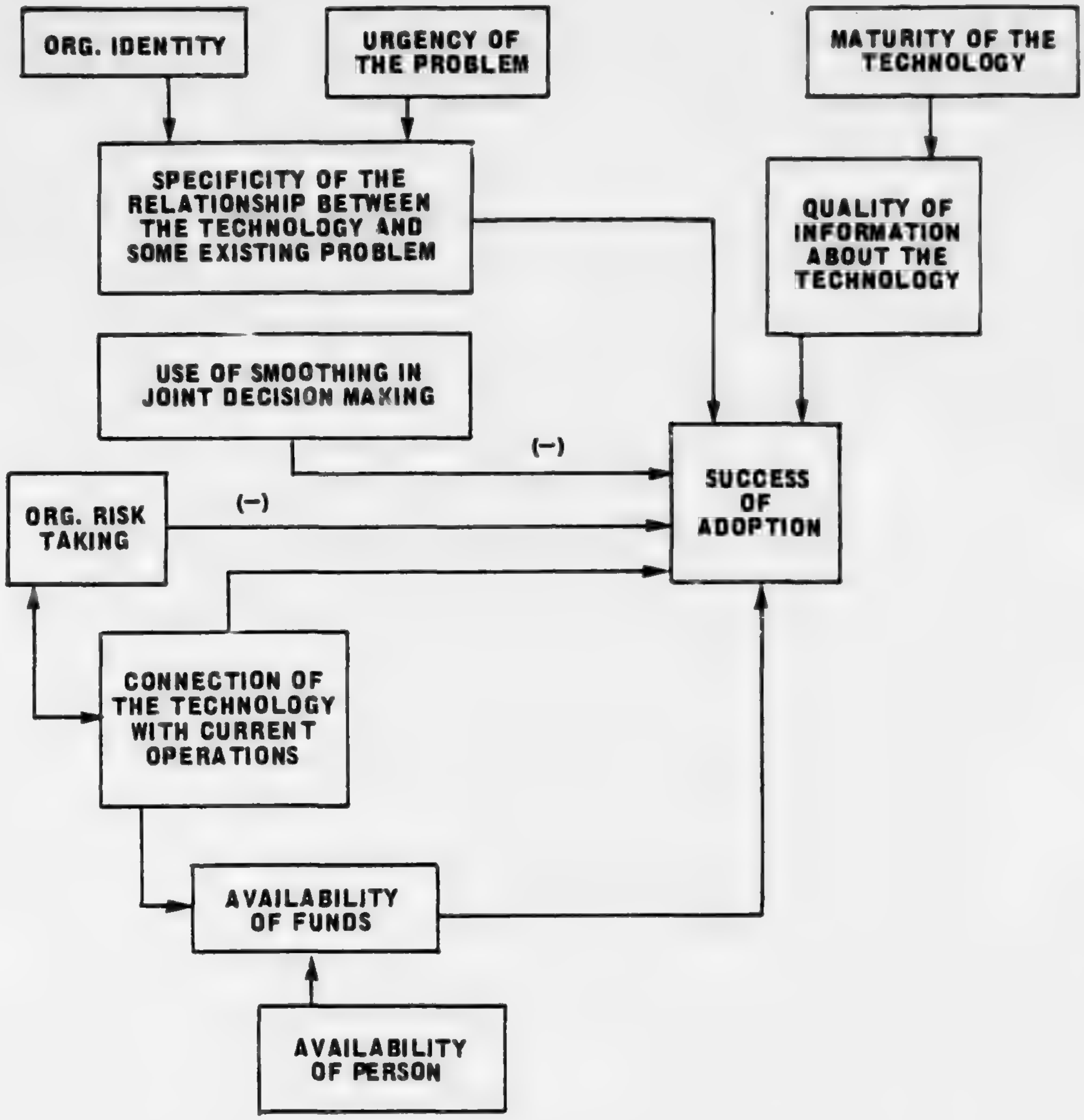


(YOUNG, E.C. AN ANALYSIS OF FACTORS INFLUENCING THE DECISION TO ADOPT CHANGES IN PRODUCTION TECHNOLOGY IN SELECTED CHEMICAL FIRMS IN MEXICO AND COLUMBIA. PH.D DISSERTATION (1972)

APPENDIX B

EXHIBIT 2

THE DECISION MAKER'S PERCEPTUAL PATTERN AS IT INFLUENCES THE DECISION TO ADOPT CHANGES IN PRODUCTION TECHNOLOGY

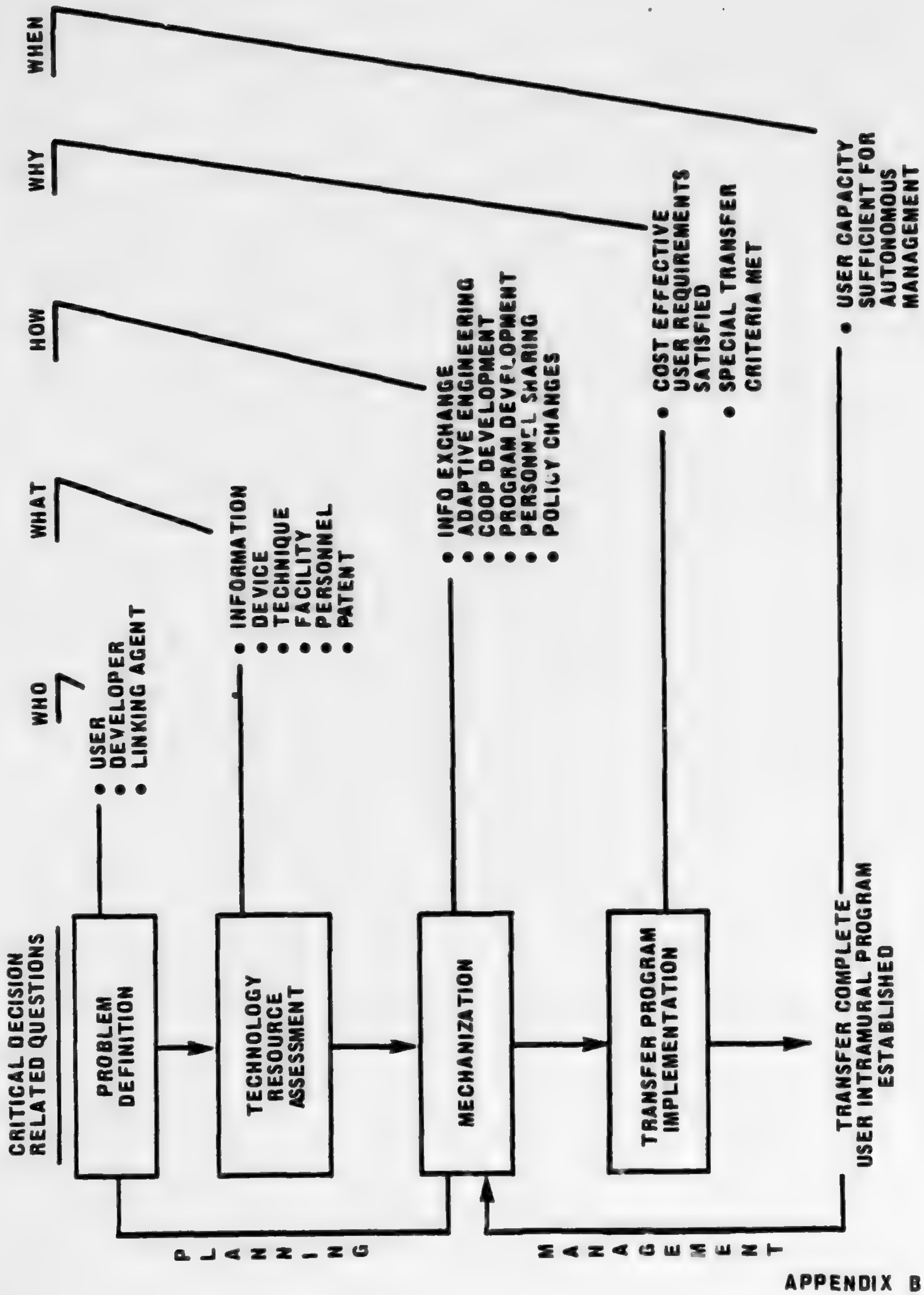


(CHAKRABARTI, ALOK THE EFFECTS OF TECHNO-ECONOMIC AND ORGANIZATIONAL FACTORS ON THE ADOPTION OF NASA INNOVATIONS BY COMMERCIAL FIRMS IN THE U.S., PH.D DISSERTATION, 1972)

APPENDIX B

EXHIBIT 3

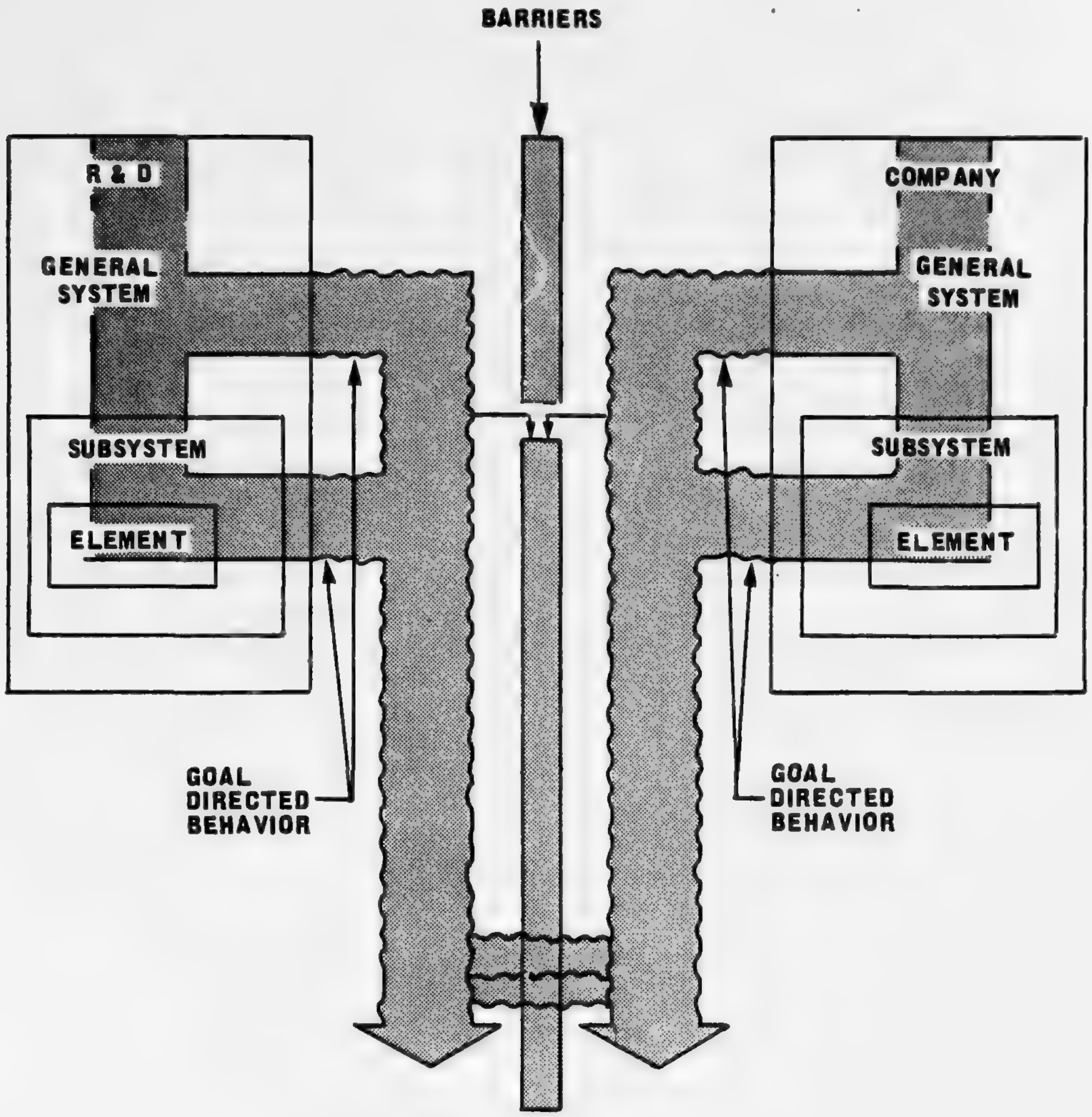
MODEL FOR PROCESS CASES OF TECHNOLOGY TRANSFER



APPENDIX B

EXHIBIT 4

TECHNOLOGY TRANSFER PROCESS



TECHNOLOGY TRANSFER AND UTILIZATION
NOT ACHIEVED

APPENDIX C

EXHIBIT 1

EXISTING TECHNOLOGY TRANSFER ENVIRONMENT

ROGERS AND SHOEMAKER'S GENERALIZATIONS RELATED TO ADOPTERS OF INNOVATION

Socioeconomic Characteristics:

1. Earlier adopters are not different from later adopters in age.
2. Earlier adopters have more years of education than later adopters.
3. Earlier adopters are more likely to be literate than are later adopters.
4. Earlier adopters have higher social status than later adopters.
5. Earlier adopters have a greater degree of upward social mobility than later adopters.
6. Earlier adopters have larger sized units than later adopters.
7. Earlier adopters are more likely to have a commercial economic orientation than are later adopters.
8. Earlier adopters have a more favorable attitude toward credit than do late adopters.
9. Earlier adopters have more specialized operations than later adopters.

Personality Variables:

1. Earlier adopters have greater empathy than later adopters.
2. Earlier adopters are less dogmatic than later adopters.
3. Earlier adopters have a greater ability to deal with abstractions than later adopters.
4. Earlier adopters have greater intelligence than later adopters.
5. Earlier adopters have a more favorable attitude toward change than later adopters.
6. Earlier adopters have a more favorable attitude toward risk than later adopters.
7. Earlier adopters have more favorable attitudes toward education than later adopters.
8. Earlier adopters have a more favorable attitude toward science than later adopters.
9. Earlier adopters are less fatalistic than later adopters.

APPENDIX D

EXHIBIT 1

10. Earlier adopters have higher level of achievement motivation than later adopters.
11. Earlier adopters have higher aspirations than later adopters.
12. Earlier adopters have greater rationality than later adopters.

Communication Behavior:

1. Earlier adopters have more social participation than late adopters.
2. Earlier adopters are more highly integrated with the social system than later adopters.
3. Earlier adopters are more cosmopolite than later adopters.
4. Earlier adopters have more change agent contact than later adopters.
5. Earlier adopters have greater exposure to mass media communication channels than later adopters.
6. Earlier adopters have greater exposure to interpersonal communication channels than later adopters.
7. Earlier adopters seek information more about innovations than later adopters.
8. Earlier adopters have a higher degree of opinion leadership than later adopters.
9. Earlier adopters have greater knowledge of innovation than later adopters.
10. Earlier adopters are more likely to belong to systems with modern rather than traditional norms than are late adopters.
11. Earlier adopters are more likely to belong to well integrated systems than later adopters.

NAVAL OFFICER

PROFESSIONAL PREFERENCE CENSUS

1. Assuming that you were to make the Navy a career, what would be the highest rank to which you would aspire?

   a) Lieutenant Commander
   b) Commander
   c) Captain
   d) Rear Admiral
   e) Admiral

2. Indicate the type of information upon which you would place highest credibility.

   a) Personal knowledge
   b) Associated staff
   c) Vendors and/or trade councils
   d) Literature-journals, books, etc.
   e) Analysis and experimentation

3. Indicate which word, when placed in the following sentence, would most accurately describe you: I feel that I hear about new work-related developments in my professional area ________________

   a) considerably before
   b) sooner than
   c) at about the same time
   d) later than
   e) sometime after

4. In the past year, how many nonroutine, work-related projects have been completed for which you supplied the original idea?

   a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

5. Indicate the number of technical and/or scientific society meetings and/or conventions which you attended last year which involved personnel other than your immediate circle of colleagues.

   a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

6. When you are on the job, do you most prefer work that is:

   a) concerned with accomplising a specific task
   b) concerned with attempting to solve a challenging but not specifically assigned task

APPENDIX E

EXHIBIT 1

c) concerned with accomplishing those tasks for which I am individually responsible
d) concerned with the efficient utilization of resources
e) none of the above

7. In the past month how many times have you sought further information about a new idea or ideas which you thought to be useful to your work?

   a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

8. Mr. E., a civil engineer, who is married and has three children recently decided to perform some major improvements upon his house (cost approximately $1,000). Mr. E. realized that the improvements were not urgently required but would make life at home more comfortable for the E. family. Consequently, Mr. E. was faced with a decision as to how he should finance the home improvements because such seemed to be the sole determinant as to when the E's could utilize these improvements. Indicate which of the following financial decisions you would advise Mr. E., to make for his home improvements.

   a) Borrow the necessary money immediately at 18% annual interest.
   b) Save for 6 months and borrow the remainder at 10% annual interest.
   c) Save for one year and borrow the remaining at 7% annual interest.
   d) Save for two years and pay cash for the improvements if present interest rates remain the same.
   e) Make no improvements.

9. Indicate the frequency with which your subordinates, peers, and/or superiors came to you in the past month for work-related information and/or advice which was not a function of your formal position.

   a) 1-3 b) 4-9 c) 10-15 d) 16-20 e) More than the above.

10. Indicate the total number of journals, magazines, and newspapers which you regularly read:

   a) 1-2 b) 3-4 c) 5-6 d) 6-8 e) More than the above

11. Indicate the number of technical, scientific, and/or professional societies to which you hold <u>current</u> membership.

a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

12. Indicate the level within the social strata to which you would aspire to be <u>10 years</u> from now.

a) Upper
b) Lower-Upper
c) Upper-Middle
d) Middle
e) Lower-Middle

13. Mr. C., a civil engineer, who is employed by a medium sized construction firm recently learned of a new building material which is used extensively in Europe but never adopted in the United States. The building material appears to have several <u>advantages</u> in terms of substantial cost reduction, superior insulation qualities, and relative ease of construction as compared to its counter part in the United States.

After a thorough investigation, Mr. C. obtained <u>extensive</u> and <u>reliable</u> information on the characteristics, costs, and advantages of the new material. Further, his company could easily obtain exclusive manufacturing rights for use in the United States.

Imagine that you are Mr. C. Indicate which of the following would best describe your approach to the building material.

a) Recommend that the new idea be utilized in the firm's next major building project so as to take advantage of the substantial cost savings.
b) Recommend that the building material be used in one of the firm's small, local building projects so as to test its acceptance.
c) Recommend that the firm construct a non-commercial prototype.
d) Recommend that the firm engage the services of an independent consultant firm so as to verify the information obtained and to test market acceptance.
e) Recommend that the firm wait until the building material has received considerable commercial application in the United States.

14. In your experience, which of the following do you tend to rely most heavily upon as a source of technical information for work-related projects and/or problems?

   a) Literature-books, government manuals, and professional trade and technical journals.
   b) Vendors-representatives of, or documentation generated by suppliers or potential suppliers.
   c) Personal experience-ideas which were previously used by yourself in similar situations and recalled directly from memory.
   d) Staff-selected members of your staff who are not assigned directly to the project being considered.
   e) External sources-sources which do not fall into any of the above categories.

15. Indicate the group of people to whom you primarily relate.

   a) Officers within your specialized field.
   b) Work-related colleagues (both military and civilian).
   c) Community associates.
   d) I have a primary reference group but it is people other than those listed above.
   e) I do not have a primary reference group.

16. During the last month, indicate the relative frequency with which you recommended a specific item of interest, e.g., journal article, research report, or a lead to either to a colleague which dealt with a work-related topic.

   a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

17. Mr. A., a middle management executive, who is married and has one child, has been working for a corporation since graduation from college five years ago. He is assured of a lifetime job with a modest, though adequate, salary, and liberal pension benefits upon retirement. On the other hand, it is very unlikely that his salary will increase much before he retires. While attending a convention, Mr. A. is offered a job with a small, newly founded company which has a highly uncertain future. The new job would pay more to start and would offer the possibility of a share in the ownership if the company survived the competition of the larger firms.

   Imagine that you are advising Mr. A. Listed below are several probabilities or odds of the new company's proving financially sound.

Please check the lowest probability that you would consider acceptable to make it worthwhile for Mr. A. to take the new job.

a) The chances are 1 in 10 that the company will prove financially sound.
b) The chances are 3 in 10 that the company will prove financially sound.
c) The chances are 5 in 10 that the company will prove financially sound.
d) The chances are 7 in 10 that the company will prove financially sound.
e) The chances are 9 in 10 that the company will prove financially sound.

18. Indicate which of the following best characterizes your approach to an innovative idea:

a) Very eager to adopt new ideas
b) Discreet use of new ideans
c) Deliberate for sometime before adopting a new idea
d) Skeptical and cautious about adopting a new idea
e) Prefer to only use proven ideas

19. Biographical data.

a) Please indicate the type of organization you are working in at the time.

____

b) Please indicate the title of your billet and present rank. ______________________________
c) How many years have you held your present rank? ____
d) How many years did you hold your previous rank? ____

Scoring for Naval Officer Professional Preference Census:

Question	Number of Points a	b	c	d	e
1	1	2	3	4	5
2	5	4	3	2	1
3	5	4	3	2	1
4	1	2	3	4	5
5	1	2	3	4	5
6	2	5	3	4	1
7	1	2	3	4	5
8	5	4	3	2	1
9	1	2	3	4	5
10	1	2	3	4	5
11	1	2	3	4	5
12	5	4	3	2	1
13	5	4	3	2	1
14	2	3	1	4	5
15	1	2	3	4	5
16	1	2	3	4	5
17	5	4	3	2	1
18	5	4	3	2	1

GOVERNMENT SERVICE EMPLOYEE

PROFESSIONAL PREFERENCE CENSUS

Please circle the letter which most nearly describes your answer or reaction to the question.

1. Indicate the type of information upon which you would place highest credibility.

   a) Personal knowledge
   b) Associated staff
   c) Vendors and/or trade councils
   d) Literature - journals, books, etc.
   e) Analysis and experimentation

2. Indicate which combination of words, when placed in the following sentence, would most accurately describe you: I feel that I hear about new work-related developments ________________ most of my colleagues.

   a) considerably before
   b) sooner than
   c) at about the same time as
   d) later than
   e) sometime later

3. In the past year, how many nonroutine, work-related projects have been completed for which you supplied the original idea?

   a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

4. Indicate the number of formal work-related meetings and/or conventions which you attended last year and which involved personnel other than your immediate circle of colleagues.

   a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than 6

5. Given a choice of the type of work you could perform on the job, which would you choose?

   a) a project with multiple solution methods and a broad range of possible objectives.
   b) a project with a specific objective but alternative solution methods.
   c) a pre-defined non-routine assignment.
   d) a challenging assignment in which the alternatives and objectives are determined primarily by you.
   e) a pre-defined routine assignment.

APPENDIX E

EXHIBIT 2

6. In the past month how many times have you sought further information, other than that of a routine nature, about a new idea or ideas which you thought to be useful to your work?

   a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

7. For the past 2 years a very close friend has had a strong desire to take a vacation in a foreign country. The trip will cost about $2000. He can leave anytime within the next year and could save $2000 or more in a year. What would you advise him to do?

   a) Charge the entire trip on credit.
   b) Save for 3 months with the balance credit.
   c) Save for 6 months with the balance credit.
   d) Save for 9 months with the balance credit.
   e) Save for 1 year and pay cash for the entire trip.

8. Indicate the frequency with which your subordinates, peers, and/or superiors came to you in the past month for work-related information and/or advice which was not a function of your formal position.

   a) 1-3 b) 4-7 c) 8-11 d) 11-15 e) More than the above.

9. Indicate the total number of journals, magazines, and newspapers which you regularly read:

   a) 1-2 b) 3-4 c) 5-6 d) 7-8 e) More than the above

10. Indicate the number of work-related organizations to which you hold current membership.

    a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above

11. Indicate the level within the social strata to which you would aspire to be 10 years from now.

    a) Upper
    b) Lower-Upper
    c) Upper-Middle
    d) Middle
    e) Lower-Middle

12. Mr. C., a civil engineer, who is employed by a medium sized construction firm recently learned of a new building material which is used extensively in Europe but never adopted in the United States. The building material appears to have several advantages in terms of substantial cost reduction, superior insulation qualities, and

relative ease of construction as compared to its counter part in the United States.

After a thorough investigation, Mr. C. obtained extensive and reliable information on the characteristics, costs, and advantages of new material. Further, his company could easily obtain exclusive manufacturing rights for use in the United States.

Imagine that you are Mr. C. Indicate which of the following would best describe your approach to the building material.

a) Recommend that the new idea be utilized in the firm's next major building project so as to take advantage of the substantial cost savings.
b) Recommend that the building material be used in one of the firm's small, local building projects as as to test its acceptance.
c) Recommend that the firm construct a non-commercial prototype.
d) Recommend that the firm engage the services of an independent consultant.
e) Recommend that the firm wait until the building material has received considerable commercial application in the United States.

13. Which of the following do you tend to rely upon most heavily as a source of information for work-related projects and/or problems.

a) Literature
b) Sales representatives
c) Personal experience
d) Colleagues
e) Sources external to your organization

14. With whom do you have mutual work-related interests?

a) Fellow workers.
b) People doing similar work outside your organization.
c) Community associates.
d) Several groups in your locale.
e) Many groups, not necessarily in the same geographical area.

15. During the last month, indicate the relative frequency with which you recommended to a colleague a specific item of interest on a work-related topic, e.g., a journal article, research report, or any information on new ways to do things.

a) 0 b) 1-2 c) 3-4 d) 5-6 e) More than the above.

16. Assume that for some reason a very close friend is forced to find another job. Some of the companies he has contacted are new and although their future success is uncertain, they offer potential salaries above that which he is now receiving. Indicate which company you would advise your friend to join.

	CHANCES FOR COMPANY SUCCESS	PROSPECTIVE SALARY INCREASE
a)	2 in 10	200%
b)	4 in 10	100%
c)	6 in 10	50%
d)	8 in 10	25%
e)	Survival Guaranteed	0%

17. Indicate which of the following best characterizes your approach to an innovative idea:

    a) Very eager to adopt new ideas.
    b) Discreet use of new ideas.
    c) Deliberate for sometime before adopting a new idea.
    d) Skeptical and cautious about adopting a new idea.
    e) Prefer to only use proven ideas.

18. What is your present position/GS rating? __________
    To what position/GS rating do you aspire? __________

19. How long have you worked at the job to which you are presently assigned? ________________

20. Give a brief description of the nature of your job.

Scoring for Government Service Employee Professional Preference Census:

Question	Number of Points				
	a	b	c	d	e
1	5	4	3	2	1
2	5	4	3	2	1
3	1	2	3	4	5
4	1	2	3	4	5
5	4	3	2	5	1
6	1	2	3	4	5
7	5	4	3	2	1
8	1	2	3	4	5
9	1	2	3	4	5
10	1	2	3	4	5
11	5	4	3	2	1
12	5	4	3	2	1
13	2	3	1	4	5
14	1	2	3	4	5
15	1	2	3	4	5
16	5	4	3	2	1
17	5	4	3	2	1

ORAL LINKER CENSUS

Name: ______________________________ L1; PL; NM; PS; ST

Designator: ______________________ Rank ______________

Previous Assignment: ________________ Score ______________

Note: All questions are related to the most recent tour of duty prior to DUINS at the Naval Postgraduate School.

1. Please think of a work-related new* idea which you thought about implementing at your last duty station.

   Were any attempts made to bring this idea into fruition? Yes _____ No _____

   If "yes" describe the action taken: ______________________________

   If "no" explain why: ______________________________

   If "yes" did you encounter any organizational barriers or individual objections to the idea? Yes _____ No _____.
   Explain: ______________________________

Score: 1 2 3 4 5 6 7 8 9 10

* "New" means that it is new as perceived by the individual. It matters little whether or not an idea is objectively new as measured by the amount of time elapsed since its first use or discovery.

APPENDIX E

EXHIBIT 3

2. Please think of the most recent work-related project which you completed at your last duty station.

Date project initiated: ____________________

Date project completed: ____________________

If the completion time was excessive explain: ____________________________________

____

____

Please identify the most important source of information: ____________________

____

Who supplied the initial idea for the project? ______________________________

Who recognized the need for such a project? ________________________________

Was the project specifically assigned to you? Yes ______ No ______

If "no" explain: ____

____

____

____

Were there any changes between the initial idea and the idea which was actually implemented? Yes _____ No _____

If "yes" who supplied the majority of the changes? __________________________

Comments: ____

____

____

____

Score: 1 2 3 4 5 6 7 8 9 10

3. Can you recall a work-related project which you completed at your last duty station for which you supplied the original idea? Yes ____ No ____

If yes, what was the project? ____

Where did you get the idea: ____

____

Were any barriers and/or objections encountered which deterred immediate acceptance? Yes ____ No ____

If "yes", explain: ____

____

____

____

Where did you get the majority of information from idea inception to project completion? ____

____

____

____

Did the information sources change as the project moved from initial idea to completed project? Yes ____ No ____

If "yes", explain: ____
____
____
____

Score: 1 2 3 4 5 6 7 8 9 10

4. In the context of your last duty station, please think of the most recent instance in which an item of information which you received from a source, other than someone in your immediate circle of colleagues, proved to be useful in your work.

   What was the source of the information?________________________________

Before receiving this information had you recognized a need for such information? Yes ____ No ____

If "yes", what was the length of time between recognition of the need and receipt of the information? ____

If the time duration was excessive, explain: ______________________________
____
____

If "yes" explain how you recognized the need for the information (I specifically searched for the information; someone gave this information, a lead to it, or the material containing the information, on [1] the basis of having been previously told of my interests in such information, or [2] a voluntary basis; I ran across it or a lead to it while searching specifically for some other item of information; I found it while reviewing current literature; I went directly to a person or document from which (a) I expected to find the information, or (b) I expected to find a lead to the information):________________________
____
____
____
____

Please indicate the three (3) major sources of information which you regularly use for work related innovations and/or ideas: ____________________________
____
____

Of the above which do you use most frequently?_____________________________

Why? ____
____
____
____

Score: 1 2 3 4 5 6 7 8 9 10

5. What work-related conventions did you attend in the last six months of your last duty station? ____
____
____

Of these conventions, which did you specifically request to attend? ________
____
____

Are there any conventions and/or technical, professional, or scientific society meetings which you requested to attend but were unable to do so for one reason or another? Yes ____ No ____

Explain: ____
____
____

Score: 1 2 3 4 5 6 7 8 9 10

6. Do you consider that you have a primary reference group (group of people to whom you primarily relate)?

Explain: ____
____
____
____

Indicate and explain the level of social participation which you maintain within this primary reference group: ____
____
____
____

Score: 1 2 3 4 5 6 7 8 9 10

7. General Comments:
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CREATIVE THINKING TECHNIQUES

1. Brainstorming: An intentionally uninhibited individual or group approach. The objective is to produce the greatest possible number of alternative ideas for later evaluation and development.
2. Reverse Brainstorming: Sometimes useful prior to a brainstorm session, it consists of being critical instead of suspending judgment.
   a. List all the things wrong with the operation, process, system, or product.
   b. Systematically take each flaw uncovered and suggest ways of overcoming it.
3. Catalog Technique: Simply listing various and sundry catalogs or other source of printed information as a means of getting ideas that will, in turn, suggest other ideas. May be used in combination with the Forced Relationship Technique.
4. Check-List Technique: A system of getting idea-clues or "leads" by checking the items on a prepared list against the problem or subject under consideration. The objective is to obtain a number of general ideas for further follow-up and development into specific form.
5. Free Association: A method of stimulating the imagination to some constructive purpose.
   a. Jot down a symbol-word, sketch, number, picture - which is related in some key way to some important aspect of the problem or subject under consideration.
   b. Jot down another symbol suggested by the first one.
   c. Continue until ideas emerge.

   The objective is to produce intangible ideas, advertising slogans, designs, names, etc.
6. Attribute Listing: A technique used principally for improving tangible things.
   a. Choose some object to improve.
   b. List the parts of the object.
   c. List the essential basic qualities, features, or attributes of the object and its parts.
   d. Systematically change or modify the attributes.

   The objective is to satisfy better the original purpose of the object, or to fulfill a new need with it.
7. Forced Relationship: A method which has essentially the same basic purpose as free association, but which attempts to force association.
   a. Isolate the elements of the problem at hand.

APPENDIX F

EXHIBIT 1

b. Find the relationships among these elements (similarities - differences - analogies - cause and effect).
c. Record the relationships in organized fashion.
d. Analyze the record of relationships to find the patterns or basic ideas present. Develop new ideas from these patterns.

8. Morphological Analysis: A comprehensive way to list and examine all of the possible combinations that might be useful in solving some given problem.
   a. State your problem as broadly and generally as possible.
   b. Define the independent variables present in the problem - as broadly and completely as possible.
   c. Enter the variables as the axes of a morphological chart - or make a permutational listing.
   d. Select the most promising alternatives and follow them through.

   The objective is to find all of the possible combinations for subsequent testing, verification, modification, evaluation and development.

9. Input-Output Technique: A method of solving dynamic system-design problems:
   a. Investigate direction (input, resources, etc.).
   b. Establish measures for testing.
   c. Develop methods.
   d. Optimize a structure.
   e. Accomplish a structure.
   f. Convince others of its value.

   The objective is to produce a number of possible solutions which can then be tested, evaluated and developed.

10. Synectics: A structured approach to creative thinking using the following operational mechanisms.
    a. Making the strange seem familiar (through analysis, generalization, and model-seeking).
    b. Making the familiar seem strange (through personal analogy, direct analogy, and symbolic analogy).

    The objective usually is to produce one best idea and to carry it through to testing, verification, development, and production in final form.

11. Inspired (Big Dream) Approach: A "breakthrough" approach which sometimes leads to spectacular advancements.
    a. Think the biggest dream possible about something to benefit mankind.
    b. Read, study, and think about every subject connected with your big dream, and do so regularly, persistently, continually.
    c. Drop down a dream or so, then engineer your dream into reality.

The objective is to make the greatest possible achievement for human benefit.

12. Edisonian Method: An approach consisting principally of performing a virtually endless number of trial-and-error experiments. A "last-ditch" approach, to be resorted to only when
    a. Other, more systematic methods have completely failed to produce the desired results; and/or
    b. One is knowingly and necessarily delving into the unknown, into areas of basic research.
13. Kepner-Tregoe Method: A method particularly calculated to isolating or finding the problem and then deciding what to do about it. A systematic outline is made to describe precisely both the problem and what lies outside the problem but is closely related to it in order to find possible causes of the problem and facilitate decision making.
14. Bionics: Ask yourself, "How is this done in nature?" Nature's scheme of things is revealed to those who search. (Note: this technique may come into play in synectics when utilizing analogies.)
15. Value Analysis (or Engineering): A specialized application of creative problem solving to increase value. It may be defined as an objective, systematic and formalized method of performing a job to achieve only necessary functions at minimum cost. Six questions are evoked concerning each part:
    a. What is it?
    b. What must it do?
    c. What does it do?
    d. What did it cost?
    e. What else will do the job?
    f. What will that cost?
16. Scientific Method: Although many scientists today say there is no one "scientific method" the following general approach is by now regarded as traditional and is listed here for comparative purposes.
    a. Define the problem.
    b. Analyze the problem.
    c. Gather data to solve the problem.
    d. Analyze the data.
    e. Arrive at solutions.
    f. Test these solutions.

[Miller, 1970]

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